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COLORADO
1974

TECHNICAL INVESTIGATIONS BRANCH
SURVEILLANCE AND ANALYSIS DIVISION
U. S. ENVIRONMENTAL PROTECTION AGENCY
REGION VIII

JULY 1977

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ABSTRACT

To develop additional information on the effect of point and non-point sources of wastes and on the trophic condition of the three lakes, the Technical Investigation Branch, Surveillance and Analysis Division, Region VIII, EPA conducted an investigation of Grand, Shadow Mountain, and Granby Lakes. The study, conducted in June and repeated again in September, 1974, concentrated on 1) the determination of the existing nutrient level in each of the lakes; 2) the determination of the existing organic and nutrient loadings from point and non-point sources; and 3) the determination of the probable consequences of increased nutrient levels in the three lakes as regards nuisance algal growths. Sampling was conducted at 71 locations throughout the study area.

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INTRODUCTION

Grand Lake, Shadow Mountain Lake, and Lake Granby, surrounded by the scenic natural setting of Rocky Mountain National Park and the Arapahoe National Forest, have received increasing attention over the years as a valuable recreational resource area. The great appeal of this type of natural setting has led to the development of numerous tourist facilities and summer homes along the shores of each of the lakes.

As development continued over the years and became ever more sprawling, concern about the effects of this growth on the water quality of the lakes became an issue of increasing importance. This concern prompted numerous investigations of the three lakes area by Federal, State and local agencies and institutions (Pennak, 1955; EPA, 1970; Nelson, 1971; Kugrens & Paulsen, 1972).

A recent proposal by the Three Lakes Water and Sanitation District called for the elimination of point-source discharges from wastewater treatment facilities as well as individual septic tank treatment systems in the drainage area of the three lakes. To develop additional information on the effect of point and non-point sources of wastes and on the trophic conditions of the three lakes, an investigation of Grand, Shadow Mountain, and Granby Lakes was conducted. This investigation was conducted in two phases. Phase I, conducted in June, 1974, was developed to define water quality prior to the heavy-use summer season. Phase II, conducted in September of the same year, was to define water quality after the summer season. The study concentrated on the following objectives:

1. To determine the existing nutrient level in each of the Three Lakes.
2. To determine the existing organic and nutrient loadings from point and non-point sources to the Three Lakes where possible, specifically, the organic and nutrient loading from the Grand Lake wastewater treatment plant, the National Park campground, individual septic tank type systems and other contributory inputs.
3. To determine the probable consequences of increased nutrient levels in the Three Lakes as regards nuisance algal growths.

The investigation as related to item (3) included a laboratory study of the algal growth potential of each of the three lakes. Also included was an algal assay of the Colorado River outlet from Lake Granby to determine the algal growth potential of water leaving the three lakes system.

SUMMARY AND CONCLUSIONS

The intensive two-phase sampling program conducted in the Three Lakes system during the summer and fall of 1974 has produced a significant amount of current water quality and biological information which should aid in making knowledgeable decisions concerning the future management of natural resources in the Three Lakes area. A serious attempt has been made to respond as clearly as possible to the objectives presented in the introductory section of this report. The following discussion summarizes the major findings of this study.

1. In accordance with the first objective, organic, nutrient, and microbiological point source and tributary loadings to the Three Lakes have been measured and tabulated. The major point-source discharge to the Three Lakes (Grand Lake Wastewater Treatment Plant), although contributing no more than 2% of the total measured pollution load (organic and nutrient) entering the Three Lakes during the early low-tourist impact period, produced approximately 9% of the BOD load and 20% of the total phosphorus load entering the Three Lakes during the late summer heavy-use season.

2. Non-point source pollution contribution was reflected in the fact that, during the late summer sampling period, four tributary streams draining areas of significant population densities contributed approximately one-half of the flow entering the Three Lakes from all tributaries but almost three-fourths of the suspended solids and total phosphorus loads. Coliform densities were also approximately 20 times higher in these four streams than in the other six streams draining non-populated areas. It was not possible to determine site-specific, non-point source loadings other than to determine upstream loadings above possible man-caused pollution and downstream loadings at the stream mouth. Such measurements on Stillwater Creek and the North Fork of the Colorado River showed that increases in downstream organic, solids, and nutrient loadings ranged from 150 to 500% and from 50 to 120%, respectively for the various parameters in the two streams in September 1974. Soda Creek did not exhibit similar increases in pollution loads because the downstream flow was greatly reduced by upstream diversions.

3. Intensive near-shore lake sampling in areas containing significant numbers of septic tank systems (particularly the Grand Lake shoreline) did not identify any problem with microbiological pollution of the Three Lakes from septic tank systems. However, fecal coliform concentrations in Little Columbine Creek, which drains the Columbine Lake recreation home development area, ranged as high as 3000 per 100 ml in September.

4. Fecal streptococcus typing was conducted on samples from several selected areas, and the results suggest the possibility that, at certain times, human fecal contamination exists near the Shadow

Mountain Lake boat docks, in the Grand Lake Wastewater Treatment Plant effluent, and near the mouths of Stillwater, Soda, and Little Columbine Creeks. Continued microbiological monitoring in these areas appears warranted.

5. Measurements to determine the existing nutrient levels in each of the Three Lakes showed significant seasonal variation in total nitrogen and total phosphorus concentrations in Grand Lake, with less variation noted in Shadow Mountain Lake and Lake Granby. Except for nitrite plus nitrate, there does not appear to be a significant increase in nutrient concentration with depth in any of the lakes. When bottom sediments were slightly disturbed during bottom water sampling, the total nitrogen and total phosphorus concentrations increased approximately 3 and 7.5 times, respectively.

6. Dissolved oxygen concentrations in the lakes at mid- and maximum depths were generally not greatly depleted, except for Grand Lake at the maximum depth (1.7 mg/l). Other than this one "low" value, dissolved oxygen concentrations were slightly higher than previously reported values. However, there is insufficent data to conclude that dissolved oxygen concentrations in the Three Lakes have either improved or deteriorated since the earlier studies.

7. Primary productivity values were determined for each lake and, in general, were low. No increases in values reported during studies conducted six and nine years earlier were noted.

8. On the basis of the nutrient concentrations and productivity values obtained during this study, each of the Three Lakes could presently be classified as mesotrophic to eutrophic. However, this trophic status should not be considered a completely stable condition in view of the present and past history of nuisance aquatic plant growths in Shadow Mountain Lake and the past history of large numbers of blue green algae along with lower dissolved oxygen concentrations in the Three Lakes.

9. Aquatic plant growths of Elodea sp. increased very significantly in areal coverage in Shadow Mountain Lake during the summer of 1974.

10. Algal assays conducted in the laboratory revealed that increases in nutrient concentrations in the Three Lakes could result in increased algal productivity. In general, algal growth in each of the Three Lakes of the time of sampling was limited by nitrogen concentrations. Additions of nitrogen and phosphorus in combination usually resulted in the highest standing crops observed. Grand Lake exhibited, at the time of sampling, a possible secondary limitation of a nutrient other than nitrogen or phosphorus. Dry weight yields in the controls indicated a moderate to moderately high primary productivity potential. Due to incongruities in the algal assay and associated chemical data, additional algal assays are felt necessary.

DESCRIPTION OF STUDY AREA

Grand Lake, Shadow Mountain Lake and Lake Granby (The Three Lakes) are located in Grand County, Colorado, north of the Town of Granby and within a three hour drive from the Denver metropolitan area (Figure 1). The Three Lakes, surrounded almost entirely by Rocky Mountain National Park and the Arapahoe National Forest, are a major attraction of the area.

The Three Lakes encompass a drainage basin of approximately 1,023 square kilometers (395 sq. mi.) which includes the Colorado River and nine other tributary streams (Figure 1). The basin contains large areas of National Forest lands and much smaller areas of livestock grazing lands, mountain subdivisions, and tourist facilities. The various land-use types have been identified in previous studies of the area.

The basin also includes the largest natural body of water in the State of Colorado - Grand Lake. This lake has a maximum depth greater than 61 meters (200 ft), a surface area of 204 hectares (504 acres) and a normal surface elevation of 2, 551 meters (8,367 ft). It also serves as the home of the world's highest registered yacht anchorage and the traditional Lipton Cup Race in August of each year. Natural tributary inflow to Grand Lake is via the North Inlet and East Inlet streams. Additional inflow is received at times from man-made Shadow Mountain Lake. Water leaves Grand Lake either via the Alva B. Adams tunnel under the Continental Divide to the east or by natural gravity flow westward into Shadow Mountain Lake. Both exit routes are part of the overall design of the Colorado-Big Thompson Project which was built by the Bureau of Reclamation in the late 1940's primarily to provide additional irrigation water for Eastern Colorado. Today the waters of the Three Lakes serve additional diverse purposes, such as power production, fishing, boating, water contact sports, and public water supplies.

Shadow Mountain Lake is impounded by a low concrete dam across the Colorado River downstream from Grand Lake and is fed naturally by the North Fork of the Colorado River and by overflow from Grand Lake, or, alternatively, by pumped flow from Lake Granby via the Granby Pump Canal. Water can, therefore, move in either direction through Shadow Mountain Lake, depending on Eastern Slope water supply demands. The lake has an average depth of 3 meters (10 ft) and a surface area of 749 hectares (1852 acres) at a maximum surface elevation of 2,551 meters (8,367 ft). Although provisions are incorporated to permit drawing down Shadow Mountain Lake without affecting Grand Lake, the normal practice is to maintain the two lakes at the same elevation.

Lake Granby provides the majority of water storage for the Colorado-Big Thompson Project. It is fed by the outflow from Shadow Mountain Lake, the Willow Creek Canal from Willow Creek Reservoir, and by six significant tributaries. Lake Granby has an average depth of 22.6 meters (74 ft) and a surface area of 2,938 hectares (7,260 acres) at a maximum surface elevation of 2,524 meters (8,190 ft). The outlet of the face of Granby Dam is set

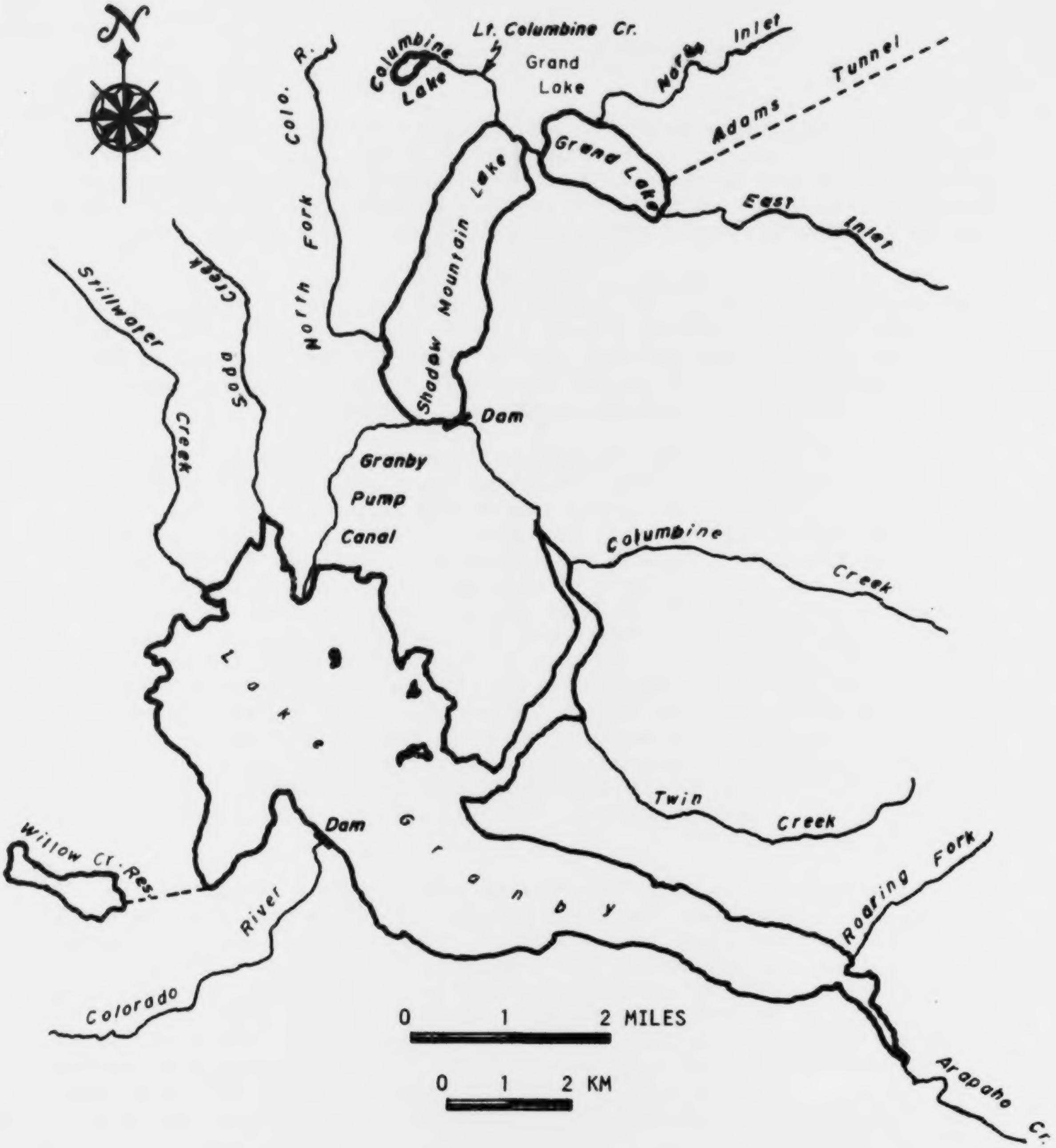
N
Lt. Columbine Cr.
Columbine Lake
Grand Lake
North Inlet
Adams Tunnel
Grand Lake
East Inlet
Colo. R.
North Fork
Shadow Mountain Lake
Dam
Stillwater Creek
Soda Creek
Granby Pump Canal
Columbine Creek
Lake Granby
Twin Creek
Dam
Willow Cr. Res.
Colorado River
Roaring Fork
Arapaho Cr.
0 1 2 MILES
0 1 2 KM

Figure 1. General location map. Grand Lake, Shadow Mountain Lake, Lake Granby.

between elevations 2,485 meters (8,150 ft) and 2,497 meters (8,190 ft), but active storage extends downward to elevation 2,496 meters (8,186 ft), providing a maximum drawdown of 28.6 meters (94 ft).

The normal flow pattern in the Three Lakes during spring runoff periods from May through June is from Grand Lake through Shadow Mountain Lake to Lake Granby. From July through April, depending on seasonal Eastern Slope water demands, water is pumped from Lake Granby through Shadow Mountain Lake to Grand Lake where it exits through the Adams Tunnel.

SURVEY METHODS

To determine existing water quality conditions in Grand Lake, Shadow Mountain Lake, Lake Granby and tributaries, the following sampling stations were established: (1) fifty-five locations in the lakes at selected cross-sections and other points, (2) thirteen locations on the tributaries feeding the three lakes, (3) one location on the Colorado River immediately downstream from Lake Granby, and (4) the effluent from the Grand Lake Wastewater Treatment Plant and the Shadow Mountain Recreation Area STP Pond (Figures 2, 3, and 4).

All water quality samples collected were "grab" type samples. Field determinations were made for temperature, pH, conductivity, dissolved oxygen, alkalinity and turbidity, with additional samples collected for laboratory analyses. The laboratory determinations included 5-day biochemical oxygen demand, total coliform, fecal coliform, fecal Streptococcus, suspended solids, and nutrients (nitrogen and phosphorus series). Chlorine residual was determined in the field at the two wastewater treatment facilities. Flow measurements were made in conjunction with tributary and wastewater treatment plant sampling. All analyses were made in accordance with recommended procedures from Standard Methods, 13th Edition.

The biological portion of the investigations of Grand Lake, Shadow Mountain Lake, and Lake Granby consisted of two major subdivisions: (1) laboratory algal assays to determine the growth-limiting nutrient and (2) determination of the present trophic status of the three lakes by use of C^{14} methodology. Basic chemical parameters of alkalinity, pH, temperature and dissolved oxygen were monitored periodically throughout the summer (June - September). During this same time span, water samples for plankton analysis were also collected. The gradual increase in relative abundance of aquatic plants was also noted during the study period.

A detailed description of station locations and results of all analyses appear in Appendix A. Depth profiles recorded at selected transects on each of the three lakes appear in Appendix B.

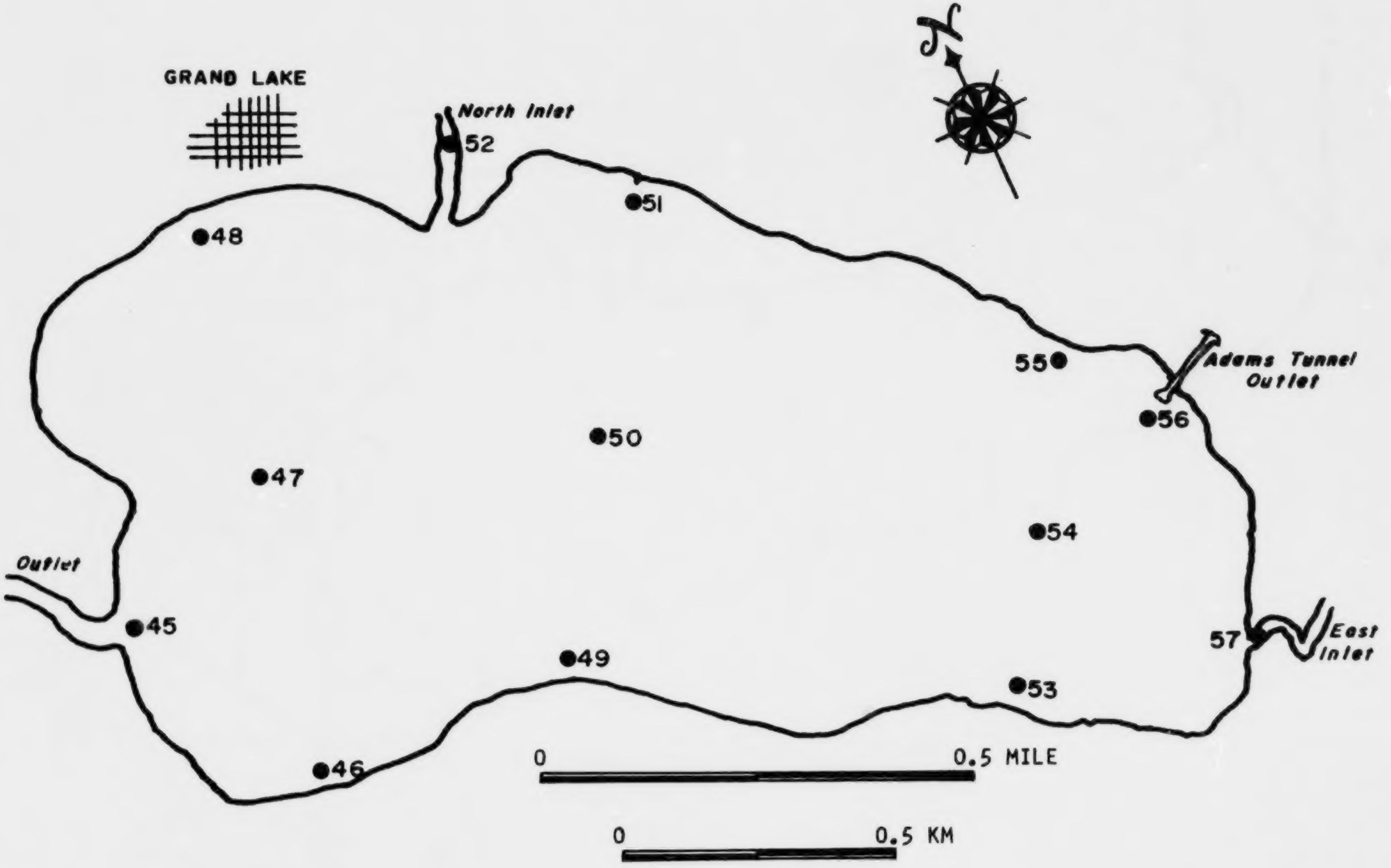
GRAND LAKE
North Inlet
52
51
48
55
56
Adams Tunnel Outlet
50
47
54
Outlet
45
49
57
East Inlet
53
46
0
0.5 MILE
0
0.5 KM

Figure 2. Station location map - Grand Lake.

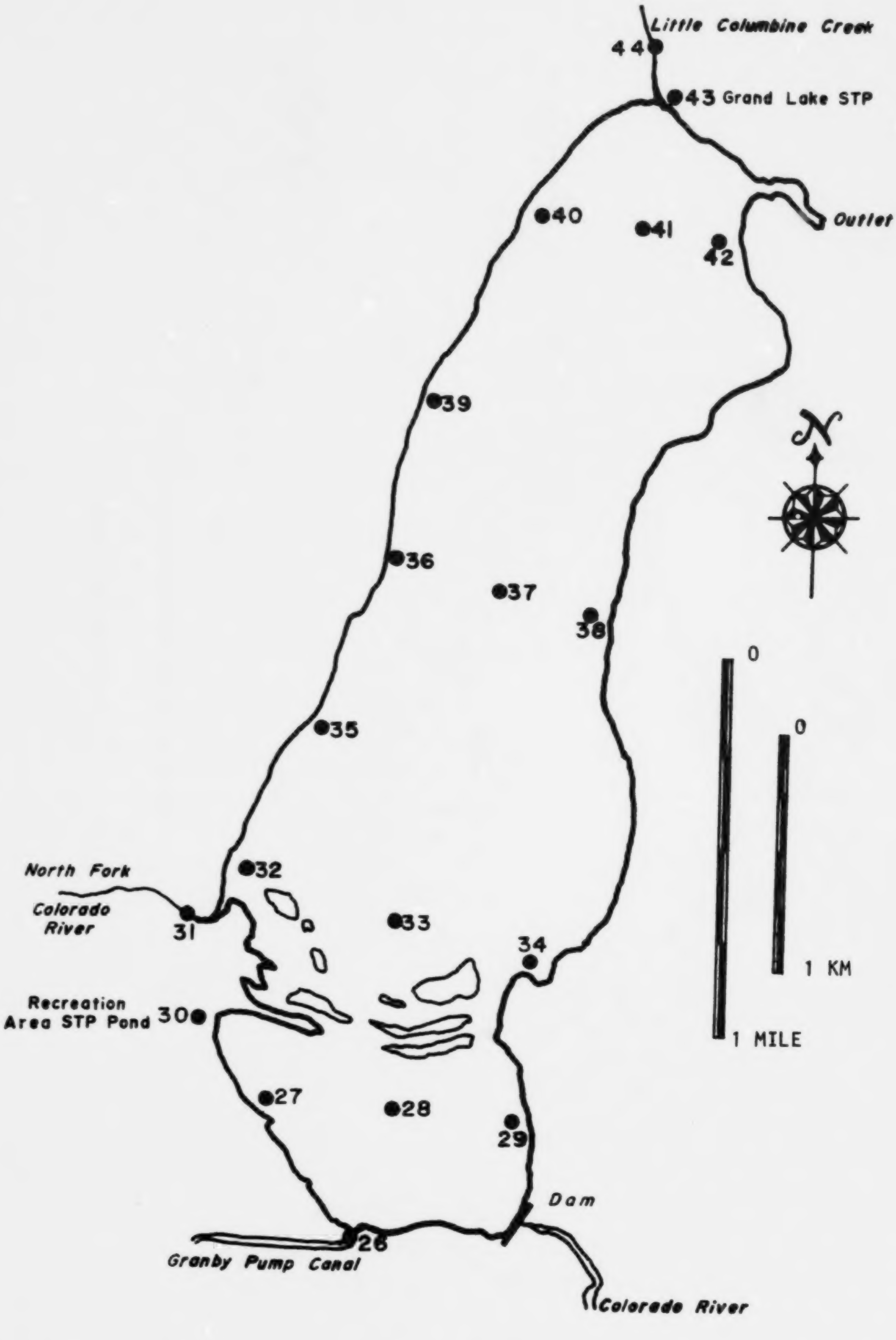
Little Columbine Creek
44
43 Grand Lake STP
40
41
42
Outlet
39
N
36
37
38
0
0
35
North Fork
Colorado
River
31
32
33
34
1 KM
Recreation
Area STP Pond
30
1 MILE
27
28
29
Dam
26
Granby Pump Canal
Colorado River

Figure 3. Station location map - Shadow Mountain Lake.

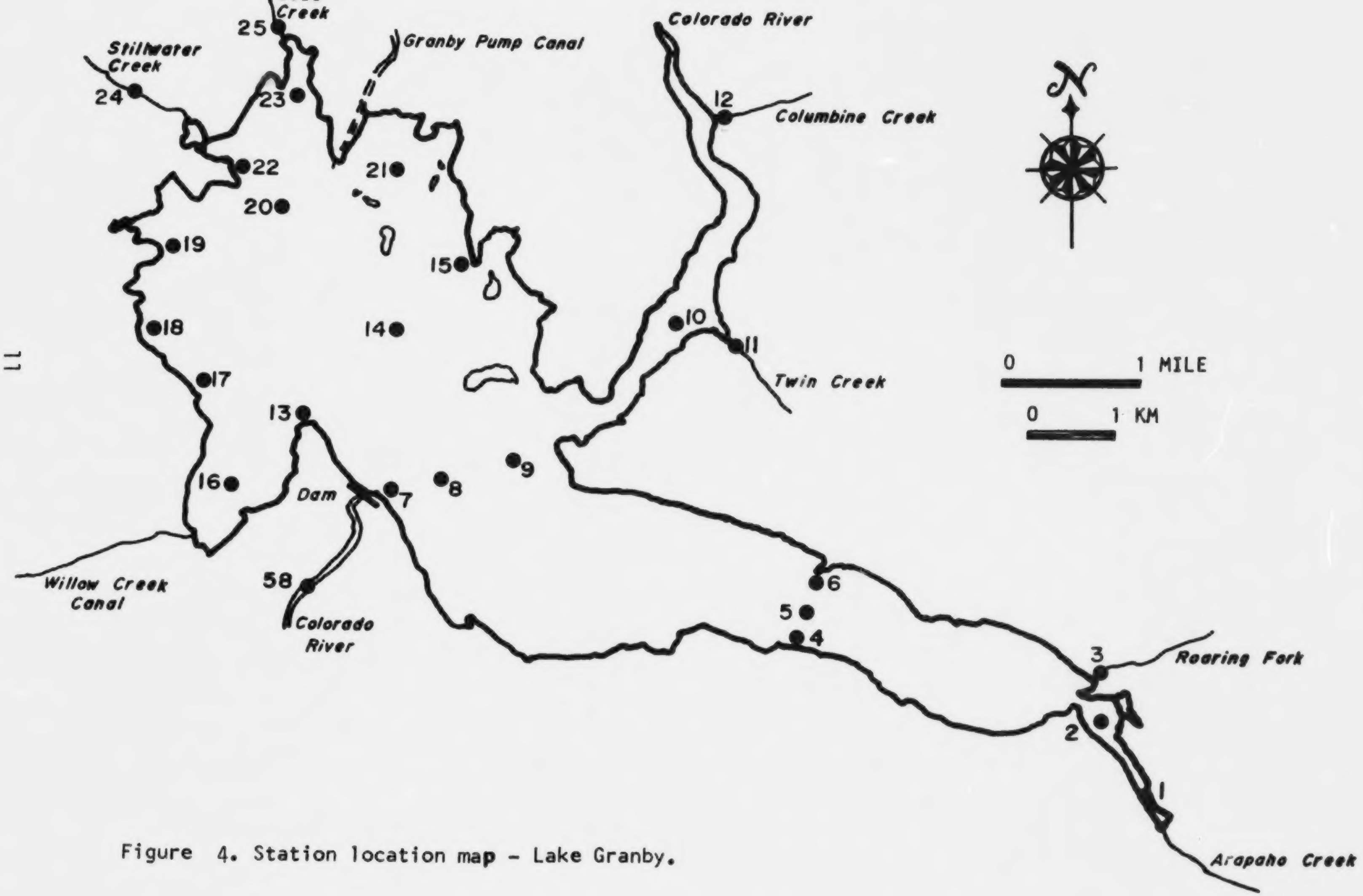
Soda Creek
25
Stillwater Creek
24
23
Granby Pump Canal
Colorado River
12
Columbine Creek
N
22
21
20
19
15
18
14
10
11
Twin Creek
0
1 MILE
0
1 KM
17
13
9
16
8
Dam
7
Willow Creek Canal
58
Colorado River
6
5
4
3
Roaring Fork
2
1
Arapaho Creek

Figure 4. Station location map - Lake Granby.

RESULTS OF STUDY

Since algal blooms were first observed in the Three Lakes system in the 1950's, there has been concern over nutrient enrichment and accelerated eutrophication of the lakes. The mechanics of eutrophication are complex, but it has long been recognized that nitrogen and phosphorus are important nutrients contributing to the eutrophication of a lake or reservoir. As a result of his study of the Wisconsin lakes, Sawyer (1947) concluded that concentrations of inorganic nitrogen in excess of 0.30 mg/l as N and inorganic phosphorus in excess of 0.01 mg/l as P at the start of the active growing season could be expected to produce nuisance algal blooms. Under certain conditions, waters containing higher concentrations of nutrients (nitrogen and phosphorus) than that considered acceptable do not become eutrophic. Likewise, there are waters where populations of nuisance organisms thrive where the concentrations of nutrients are lower than that considered as maximum. Because each body of water can react differently to a given nutrient input, it is recommended that any standards for nutrients be established on a case-by-case basis and that nutrient budgets and algal assays be used in establishing these standards.

As a general guide, it is recommended that the concentration of total phosphorus not be allowed to exceed levels of 0.1 mg/l as P in flowing waters, 0.05 mg/l in any stream entering a lake or reservoir, and 0.025 mg/l within a lake or reservoir (EPA, 1976). Although the State of Colorado has not established numerical standards for nutrients, the water quality standards do call for Class A_1 waters (the present classification for the Three Lakes) to be free from substances and conditions or combinations thereof in concentrations which produce undesirable aquatic life. A summary of Colorado Water Quality Standards for Class A_1 waters appears in Table 1.

TABLE 1

COLORADO WATER QUALITY STANDARDS SUMMARY

Standard	Class A_1
Settleable Solids	Essentially Free
Floating Solids	Essentially Free
Color, Odor, Taste	Essentially Free
Toxic Materials	Essentially Free
Oil and Grease	Essentially Free
Radioactive Material	Drinking Water Standards
Total Coliform Bacteria	Geometric Mean of less than 1000/100 ml from five samples in a 30 day period
Fecal Coliform Bacteria	Geometric Mean of less than 200/100 ml from five samples in a 30 day period
Fecal Streptococcus	Monthly Average of less than 20/100 ml from five samples in a 30 day period
Dissolved Oxygen	6.0 mg/l minimum
pH	6.5 - 8.5
Temperature	Maximum 68° F. Maximum change 2° F.
Turbidity	No increase of more than 10 J.T.U.

I. Existing Nutrient Levels in the Three Lakes

Grand Lake

Results of the water quality sampling in Grand Lake indicated higher surface concentrations of total nitrogen in June than in September (3-day averages of 0.360 mg/l and 0.266 mg/l respectively). Nitrogen concentrations at the bottom sampling points also averaged approximately 0.1 mg/l higher in June than in September. The higher total nitrogen concentrations in June may be due to the tributary contribution which averaged slightly over 1,300 lbs/day for the three-day sampling period. This loading to the lake is not simply a result of high flows in June as the actual concentrations of total nitrogen in the North and East inlet tributaries averaged about twice as high in June as in September. The total nitrogen load contributed by the two tributaries to Grand Lake in September averaged only about 20 lbs/day, a result of decreased stream flow and decreased nitrogen concentrations in the streams. There is no indication from the data that near-shore concentrations of total nitrogen increased along the more densely populated shore areas. Although nitrite plus nitrate concentrations increased with depth, there appears to be no consistent gradient of total nitrogen concentrations in Grand Lake. As shown in Tables 2 and 3, nitrite plus nitrate concentrations generally comprised less than 10% of the total nitrogen concentration.

Both surface and bottom concentrations of total phosphorus were over three times higher in June (0.021 mg/l) than in September (0.006 mg/l). This difference is reflected also by the tributary contributions of total phosphorus during the June and September sampling periods (84 lb/day and 0.19 lb/day, respectively). In, general, the variation in total phosphorus concentrations appears to be of a completely random nature which prevents one from drawing conclusions regarding human impact upon specific areas of Grand Lake. The variability also extends to the orthophosphate concentrations, which comprised approximately 10% of the total phosphorus concentration (Tables 4 and 5).

Shadow Mountain Lake

Average total nitrogen concentrations in Shadow Mountain Lake for the three-day sampling periods in June and September, ranged from a low of 0.218 mg/l to a high of 0.498 mg/l for surface water samples (Table 6). At 13 out of 15 sampling locations the average concentrations were higher in June (0.379 mg/l)[1] than in September (0.272 mg/l)[1]. This same trend is evident for total nitrogen concentrations measured in bottom water samples. In June the average concentration for the four mid-lake bottom sampling locations was 0.404 mg/l (omitting "stirred up" samples) whereas the September samples averaged only 0.273 mg/l total nitrogen.

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[1] These values represent the average total nitrogen (TKN + NO_2 + NO_3) concentration for all 15 sampling locations.

TABLE 2

AVERAGE TOTAL NITROGEN CONCENTRATIONS IN GRAND LAKE

Cross-Section Stations	Depth	Quarter Points 1 June	1 Sept.	2 June	2 Sept.	3 June	3 Sept.
45	S	0.371	0.322	-	-	-	-
	B	0.334	-	-	-	-	-
46-47-48	S	0.430	0.282	0.351	0.284	0.290	0.291
	M	-	-	0.316	0.139	-	-
	B	0.349	0.336*	0.407	0.252	0.400	0.359
49-50-51	S	0.437	0.254	0.346	0.291	0.383	0.208
	M	-	-	0.316	0.197	0.232	-
	B	0.311	0.245	0.463*	0.433	0.336	0.262
53-54-55	S	0.349	0.241	0.290	0.248	0.283	0.241
	M	-	0.189	0.475	0.230	-	-
	B	0.431	0.260	0.579	0.331	0.310	0.199
56	S	0.430	0.265	-	-	-	-
	B	0.383	0.282	-	-	-	-

S = surface
M = depth to thermocline
B = bottom

*At least one data value omitted because lake bottom was stirred up during sampling.

All concentrations in mg/l as N (TKN + NO_2 + NO_3).

Quarter point designations correspond to cross-section stations in increasing numerical order.

TABLE 3

AVERAGE NITRITE + NITRATE CONCENTRATIONS IN GRAND LAKE

Cross-Section Stations	Depth	Quarter Points					
		1		2		3	
		June	Sept.	June	Sept.	June	Sept.
45	S	0.027	0.002				
	B	0.034	-				
46-47-48	S	0.027	0.002	0.028	0.001	0.027	0.001
	M	-	-	0.036	0.039	-	-
	B	0.029	0.001	0.044	0.045	0.030	0.003
49-50-51	S	0.027	0.001	0.026	0.001	0.027	0.001
	M	-	-	0.040	0.021	0.037	-
	B	0.031	0.002	0.087	0.156	0.036	0.042
53-54-55	S	0.029	0.001	0.026	0.001	0.027	0.001
	M	-	0.025	0.035	0.027	-	-
	B	0.034	0.057	0.082	0.117	0.030	0.019
56	S	0.025	0.002				
	B	0.029	0.002				

S = surface
M = depth to thermocline
B = bottom

All concentrations in mg/l as N.

Quarter point designations correspond to cross-section stations in increasing numerical order.

TABLE 4

AVERAGE TOTAL PHOSPHORUS CONCENTRATIONS IN GRAND LAKE

Cross-Section Stations	Depth	Quarter Points 1 June	Quarter Points 1 Sept.	Quarter Points 2 June	Quarter Points 2 Sept.	Quarter Points 3 June	Quarter Points 3 Sept.
45	S	0.009	0.011	-	-	-	-
	B	0.061	-	-	-	-	-
46-47-48	S	0.009	0.007	0.009	0.006	0.010	0.005
	M	-	-	0.014	0.004	-	-
	B	0.018	0.012*	0.031	0.007	0.036	0.013
49-50-51	S	0.020	0.007	0.052	0.005	0.035	0.004
	M	-	-	0.035	0.002	0.015	-
	B	0.012	0.008	0.018*	0.007	0.027	0.005
53-54-55	S	0.019	0.005	0.015	0.005	0.028	0.005
	M	-	0.002	0.022	0.002	-	-
	B	0.027	0.012	0.063	0.003	0.022	0.006
56	S	0.022	0.004	-	-	-	-
	B	0.022	0.007	-	-	-	-

S = surface
M = depth to thermocline
B = bottom

*At least one data value omitted because lake bottom was stirred up during sampling.

All concentrations in mg/l as P.

Quarter point designations correspond to cross-section stations in increasing numerical order.

TABLE 5

AVERAGE ORTHOPHOSPHATE CONCENTRATIONS IN GRAND LAKE

Cross-Section Stations	Depth	Quarter Points 1 June	Quarter Points 1 Sept.	Quarter Points 2 June	Quarter Points 2 Sept.	Quarter Points 3 June	Quarter Points 3 Sept.
45	S	0.003	0.003				
	B	0.042	-				
46-47-48	S	0.003	0.002	0.002	0.002	0.002	0.002
	M	-	-	0.005	0.002	-	-
	B	0.007	0.004	0.004	0.003	0.005	0.002
49-50-51	S	0.002	0.001	0.002	0.001	0.002	0.001
	M	-	-	0.002	0.002	0.001	-
	B	0.001	0.002	0.006	0.002	0.004	0.002
53-54-55	S	0.002	0.002	0.002	0.001	0.003	0.001
	M	-	0.001	0.005	0.001	-	-
	B	0.003	0.002	0.008	0.002	0.002	0.002
56	S	0.002	0.001				
	B	0.002	0.002				

S = surface
M = depth to thermocline
B = bottom

All concentrations in mg/l as P.

Quarter point designations correspond to cross-section stations in increasing numerical order.

TABLE 6

AVERAGE TOTAL NITROGEN CONCENTRATIONS IN SHADOW MT. LAKE

Cross-Section Stations	Depth	Quarter Points 1 June	1 Sept.	2 June	2 Sept.	3 June	3 Sept.
26	S	0.469	0.320	-	-	-	-
27-28-29	S	0.334	0.264	0.389	0.454	0.495	0.291
	B	-	-	0.506*	0.284	-	-
32-33-34	S	0.453	0.222	0.335	0.230	0.431	0.279
	B	-	-	0.455	0.256	-	-
35	S	0.348	0.228	-	-	-	-
36-37-38	S	0.392	0.259	0.326	0.253	0.302	0.236
	B	-	-	0.279*	0.280	-	-
39	S	0.309	0.225	-	-	-	-
40-41-42	S	0.319	0.309	0.282	0.285	0.498	0.218
	B	-	-	0.378	-	-	-

S = surface
M = depth to thermocline
B = bottom

*At least one data value omitted because lake bottom was stirred up during sampling.

All concentrations in mg/l as N (TKN + NO_2 + NO_3).

Quarter point designations correspond to cross-section stations in increasing numerical order.

At least part of the differences observed when comparing results from the June and September sampling periods can be attributed to the complex hydrodynamic characteristics interrelating Grand, Shadow Mountain, and Granby Lakes. For instance, the higher total nitrogen average surface concentration observed in June in Shadow Mountain Lake (0.379 mg/l) was likely due to the influence of incoming water from Grand Lake containing an average total nitrogen concentration of 0.360 mg/l, plus the total nitrogen contributed to Shadow Mountain Lake by tributaries and the Grand Lake STP (908 lb/day). However, during the September sampling period, the flow had been reversed so that Shadow Mountain Lake was receiving water from Lake Granby via the pump canal. The reduced average total nitrogen concentration in Shadow Mountain Lake in September (0.272 mg/l) may have been influenced to a large extent by incoming water from Lake Granby containing an average total nitrogen concentration of approximately 0.320 mg/l measured in the pump canal and by greatly reduced tributary and STP loadings (55 lb/day). Additional factors related to complex biological processes may have also contributed significantly to the differences in total nitrogen concentrations observed in Shadow Mountain Lake during the June and September 1974 studies. Increased aquatic plant growth in September could have substantially reduced the total nitrogen available in water solution during this period. As was the case for Grand Lake, the NO_2 + NO_3 concentrations were quite low, comprising less than 5% of the total nitrogen concentrations in Shadow Mountain Lake.

Total phosphorus concentrations measured in Shadow Mountain Lake were fairly similar during the two study periods, ranging from an average surface concentration of 0.023 mg/l in June to 0.017 mg/l in September (Table 8). Only one station (#28) had a three-day average total phosphorus concentration in excess of 0.05 mg/l, and that was due to one unaccountably high value of 0.106 mg/l measured on June 14, 1974. Orthophosphate concentrations were in most cases less than 0.005 mg/l.

As previously noted for samples collected near the bottom of Lake Granby, nutrient concentrations in the bottom water increase dramatically when the bottom sediments are disturbed during water sampling. Three "disturbed" bottom water samples taken from the middle of Shadow Mountain Lake contained an average of 1.803 mg/l total nitrogen and 0.269 mg/l total phosphorus. Clearly, the bottom sediments have the potential to contribute significant amounts of nitrogen and phosphorus to the lake waters.

Lake Granby

There were no large variations in nitrogen concentrations among the 19 sampling stations on Lake Granby during the June and September surveys. The highest three-day average concentration was 0.534 mg/l (Station 10 - bottom sample at Grand Bay in the Colorado River Arm) while the lowest

TABLE 7

AVERAGE NITRITE + NITRATE CONCENTRATIONS IN SHADOW MT. LAKE

Cross-Section Stations	Depth	Quarter Points 1 June	1 Sept.	2 June	2 Sept.	3 June	3 Sept.
26	S	0.002	0.073				
27-28-29	S	0.001	0.020	0.002	0.041	0.001	0.047
	B	-	-	0.001	0.050	-	-
32-33-34	S	0.002	0.002	0.002	0.003	0.001	0.006
	B	-	-	0.001	0.006	-	-
35	S	0.001	0.002				
36-37-38	S	0.002	0.002	0.002	0.003	0.002	0.002
	B	-	-	0.009	0.003	-	-
39	S	0.002	0.002				
40-41-42	S	0.013	0.002	0.008	0.002	0.002	0.002
	B	-	-	0.025	-	-	-

S = surface
M = depth to thermocline
B - bottom

All concentrations in mg/l as N.

Quarter point designations correspond to cross-section stations in increasing numerical order.

TABLE 8

AVERAGE TOTAL PHOSPHORUS CONCENTRATIONS IN SHADOW MT. LAKE

Cross-Section Stations	Depth	Quarter Points					
		1		2		3	
		June	Sept.	June	Sept.	June	Sept.
26	S	0.017	0.015	-	-	-	-
27-28-29	S	0.015	0.015	0.052	0.035	0.032	0.014
	B	-	-	0.065*	0.015	-	-
32-33-34	S	0.019	0.019	0.015	0.015	0.028	0.017
	B	-	-	0.053	0.019	-	-
35	S	0.017	0.018	-	-	-	-
36-37-38	S	0.023	0.016	0.015	0.017	0.027	0.014
	B	-	-	0.019*	0.012	-	-
39	S	0.015	0.016	-	-	-	-
40-41-42	S	0.016	0.017	0.015	0.015	0.037	0.017
	B	-	-	0.036	-	-	-

S = surface
M - depth to thermocline
B = bottom

*Atleast one data value omitted because lake bottom was stirred up during sampling.

All concentrations in mg/l as P.

Quarter point designations correspond to cross-section stations in increasing numerical order.

TABLE 9

AVERAGE ORTHOPHOSPHATE CONCENTRATIONS IN SHADOW MT. LAKE

Cross-Section Stations	Depth	Quarter Points 1 June	Quarter Points 1 Sept.	Quarter Points 2 June	Quarter Points 2 Sept.	Quarter Points 3 June	Quarter Points 3 Sept.
26	S	0.005	0.005				
27-28-29	S	0.002	0.003	0.036	0.017	0.004	0.003
	B	-	-	0.007	0.003	-	-
32-33-34	S	0.005	0.003	0.003	0.002	0.004	0.002
	B	-	-	0.006	0.003	-	-
35	S	0.004	0.003				
36-37-38	S	0.004	0.002	0.003	0.001	0.004	0.001
	B	-	-	0.010	0.001	-	-
39	S	0.004	0.002				
40-41-42	S	0.003	0.002	0.003	0.001	0.004	0.001
	B	-	-	0.004	-	-	-

S = surface
M = depth to thermocline
B = bottom

All concentrations in mg/l as P.

Quarter point designations correspond to cross-section stations in increasing numerical order.

average concentration was 0.189 mg/l (Station 17-surface sample near western shoreline). Bottom concentrations, in general, were approximately 0.1 mg/l higher than surface concentrations. However, when the bottom sediments were disturbed while collecting bottom water samples, the average total nitrogen concentration increased to 0.780 mg/l, compared to 0.306 mg/l for undisturbed samples. The data showed no significant differences in total nitrogen concentrations between mid-lake samples and near-shore samples, except for the Arapahoe Bay samples (Station 2) and one sample collected near a marina on the western shoreline (Station 17). The above exceptions averaged approximately 0.1 mg/l higher than other stations (Table 10 and 11). There did not appear to be a definite total nitrogen gradient with depth at the mid-lake stations.

Total phosphorus concentrations in Lake Granby were generally uniform throughout and averaged 0.014 mg/l at the surface and 0.021 mg/l at the bottom for all samples except those collected at Station 22 (Table 13). This station is located near the campground boat launching area in Stillwater Bay and, during the June survey only, it averaged 0.147 mg/l total phosphorus for a three day period. Results from the eight samples collected after bottom disruption by sampling equipment indicate an average total phosphorus concentration of 0.137 mg/l. Samples collected from near-shore locations did not appear to contain more phosphorus than those collected in mid-lake.

II. Organic, Nutrient, and Microbiological Loading from Tributaries and Wastewater Treatment Facilities

In June 1974, 22% of the total tributary flow to the Three Lakes occurred in the populated areas drained by Stillwater Creek, Soda Creek, Little Columbine Creek and the North Fork of the Colorado River (Tables 15-18). This 22% of the total flow contributed the following percentages of the total tributary pollution load to the Three Lakes: BOD_5 - 24%; TSS - 58%; Total Nitrogen - 31%; and Total Phosphorus - 46%. Also during June, Total and Fecal Coliform densities averaged (geometrically) approximately 80 times higher in these four streams in the populated areas than in the non-populated areas.

During the September 1974 study, the four streams draining the populated areas contributed 45% of the total tributary flow to the Three Lakes. This 45% of the flow contributed the following percentages of the total tributary pollution load to the Three Lakes: BOD_5 - 41%; TSS - 71%; Total Nitrogen - 36%; and Total Phosphorus - 75%. Total and Fecal Coliform densities in the four streams draining populated areas averaged (geometrically) approximately 20 times higher than in streams draining non-populated areas. The comparisons above support the conclusion that man's activities in the populated areas of the Three Lakes region has led to higher loadings of TSS, Total Phosphorus, and Fecal Coliforms in the Three Lakes.

TABLE 10

AVERAGE TOTAL NITROGEN CONCENTRATIONS IN LAKE GRANBY

Cross-Section Stations	Depth	Quarter Points					
		1		2		3	
		June	Sept.	June	Sept.	June	Sept.
2	S	0.472	0.388	-	-	-	-
	B	0.365	0.362	-	-	-	-
4-5-6	S	0.415	0.315	0.303	0.308	0.293	0.248
	M	-	-	0.337	0.238	-	-
	B	0.327	0.355	0.278*	0.342	0.336	0.306
7-8-9	S	0.292	0.254	0.272	0.258	0.255	0.288
	M	0.282	0.265	0.275	0.285	0.290	0.254
	B	0.287*	0.344*	0.314	0.328	0.283	0.309
10	S	0.256	0.295	-	-	-	-
	B	0.432	0.534	-	-	-	-
13-14-15	S	0.274	0.228	0.254	0.318	0.271	0.260
	M	-	-	0.243	0.286	-	-
	B	0.322	0.268	0.301*	0.441	0.281*	0.319
16	S	0.263	0.299	-	-	-	-
	M	0.218	0.236	-	-	-	-
	B	0.241	0.324	-	-	-	-
17	S	0.189	0.383	-	-	-	-
	B	0.232	-	-	-	-	-

S = surface
M = depth to thermocline
B = bottom

*At least one data value omitted because lake bottom was stirred up during sampling.

All concentrations in mg/l as N (TKN + NO_2 + NO_3).

Quarter point designations correspond to cross-section stations in increasing numerical order.

TABLE 11

AVERAGE TOTAL NITROGEN CONCENTRATIONS IN LAKE GRANBY

Cross-Section Stations	Depth	Quarter Points					
		1		2		3	
		June	Sept.	June	Sept.	June	Sept.
18	S	0.201	0.266	-	-	-	-
	B	0.218	0.208	-	-	-	-
19-20-21	S	0.236	0.369	0.244	0.303	0.202	0.266
	M	-	-	0.199	-	-	-
	B	0.241	0.295	0.377	0.453*	0.349	0.436
22	S	0.252	0.299				
	B	-	-				
23	S	0.252	0.269				
	B	0.233*	0.279				

S = surface
M = depth to thermocline
B = bottom

All concentrations in mg/1 as N (TKN + NO_2 + NO_3).

*At least one data value omitted because lake bottom was stirred up during sampling.

Quarter point designations correspond to cross-section stations in increasing numerical order.

TABLE 12

AVERAGE NITRITE AND NITRATE CONCENTRATION IN LAKE GRANBY

Cross-Section Stations	Depth	Quarter Points 1 June	Quarter Points 1 Sept.	Quarter Points 2 June	Quarter Points 2 Sept.	Quarter Points 3 June	Quarter Points 3 Sept.
2	S	0.032	0.001				
	B	0.028	0.002				
4-5-6	S	0.002	0.001	0.002	0.001	0.003	0.001
	M	-	-	0.002	0.036	-	-
	B	0.024	0.001	0.054	0.096	0.009	0.002
7-8-9	S	0.002	0.001	0.002	0.002	0.002	0.001
	M	0.029	0.015	0.015	0.005	0.013	0.018
	B	0.055	0.064	0.067	0.105	0.060	0.112
10	S	0.003	0.002				
	B	0.062	0.097				
13-14-15	S	0.001	0.002	0.001	0.001	0.002	0.003
	M	-	-	0.006	0.009	-	-
	B	0.002	0.002	0.061	0.111	0.006	0.002
16	S	0.004	0.002				
	M	0.018	0.002				
	B	0.051	0.098				
17	S	0.002	0.003				
	B	0.002	-				
18	S	0.001	0.003				
	B	0.005	0.002				
19-20-21	S	0.003	0.002	0.001	0.003	0.002	0.003
	M	-	-	0.019	-	-	-
	B	0.004	0.002	0.024	0.003	0.003	0.003
22	S	0.002	0.002				
	B	-	-				
23	S	0.002	0.002				
	B	0.016	0.003				

S = surface
M = depth to thermocline
B = bottom

All concentrations in mg/l as N.

Quarter point designations correspond to cross-section stations in increasing numerical order.

TABLE 13

AVERAGE TOTAL PHOSPHORUS CONCENTRATIONS IN LAKE GRANBY

Cross-Section Stations	Depth	Quarter Points 1 June	Quarter Points 1 Sept.	Quarter Points 2 June	Quarter Points 2 Sept.	Quarter Points 3 June	Quarter Points 3 Sept.
2	S	0.006	0.017	-	-	-	-
	B	0.009	0.017	-	-	-	-
4-5-6	S	0.013	0.014	0.014	0.014	0.015	0.015
	M	-	-	0.012	0.014	-	-
	B	0.015	0.015	0.017*	0.027	0.015	0.017
7-8-9	S	0.016	0.013	0.012	0.011	0.011	0.010
	M	0.011	0.013	0.012	0.012	0.012	0.010
	B	0.009*	0.012*	0.013	0.014	0.008	0.013
10	S	0.010	00.13	-	-	-	-
	B	0.046	0.026	-	-	-	-
13-14-15	S	0.017	0.013	0.015	0.012	0.014	0.011
	M	-	-	0.019	0.014	-	-
	B	0.035	0.020	0.023*	0.013	0.015*	0.021
16	S	0.017	0.011	-	-	-	-
	M	0.016	0.012	-	-	-	-
	B	0.024	0.026	-	-	-	-
17	S	0.016	0.015	-	-	-	-
	B	0.016	-	-	-	-	-
18	S	0.019	0.012	-	-	-	-
	B	0.017	0.015	-	-	-	-
19-20-21	S	0.025	0.013	0.013	0.012	0.017	0.014
	M	-	-	0.015		-	-
	B	0.025	0.014	0.036	0.015*	0.029	0.029
22	S	0.147	0.012	-	-	-	-
	B	-	-	-	-	-	-
23	S	0.017	0.015	-	-	-	-
	B	0.022*	0.020	-	-	-	-

S = surface
M = depth to thermocline
B = bottom

*At least one data value omitted because lake bottom was stirred up during sampling.

All concentrations in mg/l as P.

Quarter point designations correspond to cross-section stations in increasing numerical order.

TABLE 14

AVERAGE ORTHOPHOSPHATE CONCENTRATIONS IN LAKE GRANBY

Cross-Section S Stations	Depth	Quarter Points					
		1		2		3	
		June	Sept.	June	Sept.	June	Sept.
2	S	0.002	0.004				
	B	0.003	0.003				
4-5-6	S	0.003	0.002	0.002	0.002	0.003	0.003
	M	-	-	0.003	0.003	-	-
	B	0.003	0.003	0.005	0.007	0.003	0.004
7-8-9	S	0.003	0.003	0.004	0.002	0.003	0.002
	M	0.003	0.003	0.003	0.002	0.003	0.002
	B	0.006	0.005	0.004	0.005	0.003	0.006
10	S	0.003	0.002				
	B	0.008	0.008				
13-14-15	S	0.004	0.001	0.004	0.001	0.003	0.001
	M	-	-	0.003	0.003	-	-
	B	0.005	0.002	0.010	0.005	0.007	0.002
16	S	0.005	0.002				
	M	0.004	0.002				
	B	0.007	0.006				
17	S	0.006	0.002				
	B	0.005	-				
18	S	0.007	0.002				
	B	0.003	0.001				
19-20-21	S	0.015	0.001	0.004	0.001	0.004	0.003
	M	-	-	0.003	-	-	-
	B	0.011	0.002	0.004	0.005	0.006	0.005
22	S	0.137	0.003				
	B	-	-				
23	S	0.006	0.004				
	B	0.007	0.004				

S = surface
M = depth to thermocline
B = bottom

All concentrations in mg/l as P.

Quarter point designations correspond to cross-section stations in increasing numerical order.

TABLE 15

TRIBUTARY LOADINGS MEASURED IN POPULATED AREAS*
(MULTIPLE USE)

Sta. #	Name	Flow cfs		Loading lb/day											
				BOD_5		TSS		T-N		$NO_2 + NO_3$		T-P		$O\text{-}PO_4$	
		June	Sept	June	Sept	June	Sept	June	Sept	June	Sept	June	Sept	June	Sept
24	Stillwater	36.2	1.8	234	17.5	7024	38.8	111	4.9	5.1	0.9	30.3	1.2	13.3	0.9
25	Soda	2.8	0.04	<16.6	0.6	151	6.7	11.2	0.2	0.1	0.002	1.1	0.04	0.7	0.03
31	North Fork Colorado	325	34.3	<1927	<185	33280	740	858	27.7	12.3	0.6	54.3	3.0	14.0	1.1
44	Little Columbine	3.7	2.7	<19.9	<17.5	239	102	9.4	4.2	0.4	0.07	1.4	3.2	0.8	0.2
	Totals	368	38.8	< 2198	< 221	40694	888	990	37	17.9	1.57	87	7.4	28.8	2.23

*Areas drained by Stillwater Creek, Soda Creek, Little Columbine Creek, and the North Fork of the Colorado River.

TABLE 16

TRIBUTARY LOADINGS MEASURED IN NON-POPULATED AREAS

Sta. #	Name	Flow cfs		Loading lb/day											
				BOD_5		TSS		T-N		$NO_2 + NO_3$		T-P		$O\text{-}PO_4$	
		June	Sept	June	Sept	June	Sept	June	Sept	June	Sept	June	Sept	June	Sept
1	Arapahoe Creek	504	19.2	<2716	166	10866	207	733	42.5	92.4	0.4	10.9	2.1	5.4	0.3
3	Roaring Fork Cr.	61.3	2.8	<330	<15	991	<15	89.2	1.24	13.2	0.2	2.6	0.09	1.0	0.02
11	Twin Creek	20.0	0.8	<108	<4.3	755	4.3	19.4	0.59	0.3	0.01	1.1	0.03	0.4	0.01
12	Columbine Creek	27.7	2.1	<149	<11.3	597	<11.3	29.9	1.80	0.9	0.02	4.2	0.06	0.3	0.01
52	North Inlet	259	13.2	<1536	<71	6980	<71	433	11.6	36.3	0.4	29.3	0.14	4.2	0.07
57	East Inlet	406	10.1	<2188	<54	8753	54	875	8.3	48.1	0.3	54.7	0.05	6.6	0.05
	Totals	1278	48.2	< 7027	< 322	28942	<363	2180	66	191	1.3	103	2.5	17.9	0.5

Table 17

	Loadings, lb/day				Populated Area Loading as % of Total	
	Non-Populated Area		Populated Area*			
Parameter	June	Sept.	June	Sept.	June	Sept.
Flow (cfs)	1278	48.2	368	38.8	22.4	44.6
BOD_5	7027	322	2198	221	23.8	40.7
TSS	28942	363	40694	888	58.4	71.0
T-N	2180	66	990	37	31.2	35.9
$NO_2 + NO_3$	191	1.3	17.9	1.57	8.6	54.7
T-P	103	2.5	87	7.4	45.8	74.7
$O-PO_4$	17.9	0.5	28.8	2.23	61.7	81.7

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* Area drained by Stillwater Creek, Soda Creek, Little Columbine Creek, and the North Fork of the Colorado River.

TABLE 18

ORGANIC, NUTRIENT, SOLIDS, AND MICROBIOLOGICAL LOADING FROM GRAND LAKE WASTEWATER TREATMENT PLANT
STATION #43

		June	September
Flow	cfs	0.37[a]	0.67
	cms	0.01	0.02
BOD_5	mg/l	34	15
TSS	mg/l	27	30
Total-N[c]	mg/l	9.8	7.1
Total-P	mg/l	1.89	1.79
Total Coli.	no/100 ml	1240[b]	2262[b]
Fecal Coli.	no/100 ml	565[b]	719[b]
BOD_5	lb/day	68	54
TSS	lb/day	54	108
Total-N	lb/day	20	25.6
Total-P	lb/day	3.8	6.5
BOD_5	kg/day	31	24
TSS	kg/day	24	49
Total-N	kg/day	9.1	11.6
Total-P	kg/day	1.7	3.0

a - The main STP lift station was out of operation during the June sampling period. Plant personnel reported that an average flow of 240,000 gallons per day (0.37 cfs) would be normal for this time of year.

b - Geometric Mean

c - TKN + NO_2 + NO_3

During June 1974, a period of high tributary flows and low tourist impact, the effect of the discharge from the Grand Lake STP on the Three Lakes system was quite minor when compared to pollution contributted by the ten tributary streams. The STP contributed only approximately two percent as much total phosphorus as entered the Three Lakes via the ten tributary streams, while all other STP pollution loads were less than one percent of the tributary load.

However, during the September study the Grand Lake STP contributed the following approximate loads expressed as a percentage of the total tributary loads: Flow - 1%; BOD_5 - 10%; TSS - 9%; T-N - 25%; and T-P - 66%. The STP must, therefore, be considered a significant source of nutrient enrichment for the Three Lakes, especially during periods of low natural stream flow. However, in order to gain a complete understanding of the relative impact of the STP on the Three Lakes system, it would be necessary to measure pollution leads from the STP and the tributary streams for a complete cycle of seasons.

III. Microbiology

Total and Fecal Coliform Data

Bacteriological measurements are often used to help define the sanitary quality of bodies of water. These measurements usually include tests for determining the densities of the various types of coliform microorganisms. In general, the total coliform group includes varying proportions of microorganisms that may have only limited sanitary significant, while the fecal coliform group, a subgroup of the total coliforms, is more directly related to the presence of possible pathogenic contamination of the water. Although not necessarily pathogenic themselves, the fecal coliforms may indicate the presence of other pathogenic microorganisms.

Total and fecal coliform measurements in Grand Lake did not reveal significant bacteriological pollution during either the June or September sampling period. The geometric average density in June was two fecal coliforms per 100 ml while in September the average was only one fecal coliform per 100 ml for all sampling locations in the lake. The data did not reveal measureable bacteriological contamination from residential septic tank systems located along the shoreline of Grand Lake.

Coliform measurements in Shadow Mountain Lake averaged two to three times higher in June than in September with the greatest density occurring near the westshore marina at Station 32 (87 total and 26 fecal coliform per 100 ml). The North Fork Colorado River enters the lake near this sample site and the data shows that higher coliform density in the river in June probably contributed to the higher densities measured at Station 32. The north end of Shadow Mountain Lake is impacted by two discharges from highly developed residential and recreational areas - Little Columbine Creek, which drains the Columbine Lake area, and the Grand Lake Wastewater Treatment Plant serving Grand Lake Village. In June fecal coliform densities of nearly 3,000 per 100 ml were observed on two out of three sampling days in Little Columbine Creek, while in September, fecal coliform densities average less than 100 per 100 ml. The Grand Lake Wastewater Treatment Plant effluent intermittently contained concentrations of extremely high fecal coliform counts (approximately 500,000 per 100 ml) during both the June and September sampling periods. The chlorine residual in the effluent was zero on two out of six sampling days, and this inadequate disinfection likely resulted in the high fecal coliform counts. When a chlorine residual was present the fecal coliform density dropped to approximately 20 per 100 ml. The combined impact of these two discharges to the north end of Shadow Mountain Lake was revealed in total and fecal coliform densities approximately three times higher there than in the remainder of the lake.

Coliform measurements in Lake Granby indicated no significant bacteriological pollution present during either the June or September studies. Most sampling sites showed slightly higher coliform densities in June than in September, but only one out of nineteen stations showed a geometric mean fecal coliform density greater than five per 100 ml. Two of the six tributaries to Lake Granby contributed significant numbers of coliforms during both June and September. Stillwater Creek contributed an average of 385 fecal coliforms per 100 ml in June while Soda Creek averaged 75 fecal coliforms per 100 ml. In September these fecal coliforms densities had decreased by approximately one half. These two streams, along with six other sampling sites, were selected for additional microbiological testing, as discussed in the following section.

Fecal Streptococcus Data

In order to gain a better understanding of the various types and origins of fecal organisms present in the Three Lakes and their tributaries, eight different sampling sites were sampled during June and September for fecal streptococcus typing. This work involves growing selected fecal coliform organisms under specific growth conditions such that the various survival and die off patterns indicate which specific bio-types and strains of the fecal streptococcus group are present. From this identification of specific strains it is then possible to deduce the most likely sources of the fecal streptococcus contamination. The occurrence of fecal streptoccous organisms in water suggests fecal contamination, while their absence indicates little or no warm-blooded animal contamination (Geldreich, 1966).

The fecal streptococcus group consists of many strains and bio-types having specific origins and diverse survival rates. Two of the more important host-specific streptococcus bio-types are the S. bovis-equinis and the S. fecalis var. The S. Bovis-equinis indicator organisms are subject to rapid die off outside the animal intestinal tract (Mundt, 1963), so that their presence in water or soil indicates recent animal contamination. The S. fecalis var. strain of fecal streptococcus organisms are predominantly human types.

There are two other fecal streptococcus bio-types which have somewhat limited sanitary significance. The ubiquitous S. fecalis var. liquefaciens may represent a substantial portion of any fecal streptococcus population in natural waters. These organisms are quite persistent and may continue to survive in soil, irrigation water, cold waters (<12°C), and other natural waters for extended periods of time. They are occasionally found in soil and water from remote areas, and these infrequent occurrences may be related to direct wildlife contamination or, occasionally, to surface run-off from snowmelt and rainfall (Van Donsel, et al, 1967).

The other fecal streptococcus bio-type having limited sanitary significance is the S. fecalis atypical strain which is found in substantial numbers in rotting vegetation (Geldreich, et al, 1964, and Langston and Bouma, 1960) and in cannery wastes (Geldreich and Kenner, 1969), but occurs only rarely in thh feces of warm-blooded animals.

Fecal streptococcus typing was performed on water samples collected in June and September from two lake stations, five stream stations, and one wastewater treatment plant effluent (Table 19 and 20). Human types of fecal streptococcus (S. fecalis var.) predominated in samples collected during both June and September near the Shadow Mountain Lake boat dock areas (Stations 35 and 39), the Grand Lake Wastewater Treatment Plant effluent, and Stillwater and Little Columbine Creeks near their confluence with Lake Granby and Shadow Mountain Lake, respectively. During September, Soda Creek also contained a preponderance of human types of fecal streptococcus. These results suggest that the Shadow Mountain Lake boat dock areas, the Grand Lake wastewater treatment plant effluent, and Little Columbine, Stillwater, and Soda Creeks are all possible recipients of human fecal pollution and warrant continued monitoring in the future.

Water samples from the North Fork Colorado River station located near Shadow Mountain Lake contained human, animal, and rotting-vegetation types of fecal streptococcus. The samples showed no significant differences in the percentages of types identified between the Spring and Fall studies. These findings would be expected for the North Fork Colorado River which flows through National Park forest and meadow lands, ranch pasture lands, and mountain home development areas. The Colorado River flowing out of Lake Granby (Station 58) did not contain fecal streptococcus types of sanitary significance.

TABLE 19

THREE LAKES STUDY

FECAL STREPTOCOCCUS IDENTIFICATION - NUMBER OF STRAINS & PERCENT OF TOTAL
JUNE, 1974

Station Number	Location	S. fecalis var.*	S. fecalis biotypes	S. bovis-equinus***	S. fecalis atypical***	S. fecalis liquefaciens**	Total No. Strains Picked	Comment	
24	Stillwater Cr.	9	0	0	0	1	10	Human Types Ubiquitous Types	90% 10%
25	Soda Cr.	4	0	0	0	6	10	Human Types Ubiquitous Types	40% 60%
31	Colorado R.	5	0	3	0	2	10	Human Types Animal Types Ubiquitous Types	50% 30% 20%
35	Shadow Mt. Lake	10	0	0	0	0	10	Human Types	100%
39	Shadow Mt. Lake	9	0	0	0	1	10	Human Types Ubiquitous Types	90% 10%
43	Grand Lake STP	7	0	0	0	3	10	Human Types Ubiquitous Types	70% 30%
44	Lt. Columbine Cr.	8	0	0	0	2	10	Human Types Ubiquitous Types	80% 20%
58	Colorado R.					1	1	Ubiquitous Types	100%

*S. fecalis var. are predominately human types.
**S. fecalis var. liquefaciens are ubiquitous (non-pollution) types.
***S. bovis-equinus and S. fecalis biotypes are predominately from animal sources and S. fecalis atypical are from rotting vegetation.

TABLE 20

THREE LAKES STUDY

FECAL STREPTOCOCCUS IDENTIFICATION - NUMBER OF STRAINS & PERCENT OF TOTAL
SEPTEMBER, 1974

Station Number	Location	S. fecalis var.*	S. fecalis biotypes	S. bovis-equinus***	S. fecalis atypical***	S. fecalis liquefaciens**	Total No. Strains Picked	Comment	
24	Stillwater Cr.	22	1	1	1	1	26	Human Types Animal Types Vegetation Types Ubiquitous Types	84% 4% 4% 4%
25	Soda Cr.	18	0	2	3	0	23	Human Types Animal Types Vegetation Types	78% 9% 13%
31	Colorado R.	2	4	0	2	0	8	Human Types Animal Types Vegetation Types	25% 50% 25%
35	Shadow Mt. Lake	4	0	0	0	0	4	Human Types	100%
39	Shadow Mt. Lake	13	0	0	4	0	17	Human Types Vegetation Types	76% 24%
43	Grand Lake STP	47	2	0	2	0	51	Human Types Animal Types Vegetation Types	92% 4% 4%
44	Lt. Columbine Cr.	21	2	0	15	0	38	Human Types Animal Types Vegetation Types	55% 6% 15%
58	Colorado R.	2	1	0	15	0	18	Human Types Animal Types Vegetation Types	11% 6% 83%

*S. fecalis var. are predominately human types.

**S. fecalis var. liquefaciens are ubiquitous (non-pollution) types.

***S. bovis-equinus and S. fecalis biotypes are predominately from animal sources and S. fecalis atypical are from rotting vegetation.

IV. Biology

Lake Stratification Measurements

Temperature profiles at the various sampling stations on Grand Lake, Shadow Mountain Lake, and Lake Granby are shown in Figures 5 to 10. The gradients were established using a Yellow Springs tele-thermometer and 60 meter line with probe. The profiles reported here are similar to and well within the range of thermal conditions reported by Nelson (1971) for 1962-66.

In general, Grand Lake and Lake Granby exhibited gradual, uniform decreases in temperature during spring and early summer. As the summer progressed, the temperature profiles showed thermal stratification occurring, with the depth and strength of the thermocoline increasing during the summer. The shallow depth of Shadow Mountain Lake in conjunction with wind action and the flow-thru characteristics of the lake generally precluded a stable thermal stratification.

The dissolved oxygen concentrations and pH values obtained during this survey are shown in Tables 21 and 22. Dissolved oxygen and pH values listed at mid-depth and separated by a slash mark are values taken from above and below the thermocline, respectively. The values listed for the two major surveys, June 7-19 and September 4-19, are average values for the three day sampling period at each station. Values for pH ranged from 6.3 to 8.5, which is considered normal for water in the Three Lakes system.

Dissolved oxygen concentrations reported here differ somewhat from dissolved oxygen concentrations previously reported for mid- and maximum depths. The lowest dissolved oxygen concentrations observed during this survey were 4.0, 6.2, and 1.7 mg/l for Lake Granby, Shadow Mountain Lake and Grand Lake, respectively. These values, except for Grand Lake (Station 50), are slightly higher than minimum values of 2.9 and 4.8 mg/l reported by Nelson (1971) for Lake Granby and Shadow Mountain Lake, respectively, in 1963-66. Nelson (1971) reported a minimum dissolved oxygen concentration of 3.9 mg/l for Grand Lake.

From Table 22 it can be seen that in Lake Granby (Stations 5, 10, 14), dissolved oxygen concentrations gradually declined in the hypolimnion throughout the summer. This same condition was also evident in Grand Lake in the lower levels of the hypolimnion as shown by the decrease in dissolved oxygen concentrations from 6.0 mg/l (June 7-19) to 2.8 mg/l (Sept. 4-19). Dissolved oxygen concentrations determined during the interim period did not show the decreasing dissolved oxygen conditions. This was likely due to the difference in sampling depth, the interim sampling being done at a maximum of 30 meters while sampling during the two major surveys was done at 90 meters. Station 50 in Grand Lake was the only sampling location in

Legend for Temperature Profiles in the Three Lakes

(Figures 5 to 10)

————————————	5/30/74
———·———·———·———	6/7-19/74
································	6/28/74
— — — — — — — — — —	7/19/74
—·—·—·—·—·—·—	8/1/74
——— ———·· ——— ———·· ———	8/14/74
— — —·— — —·— — —	9/4-19/74

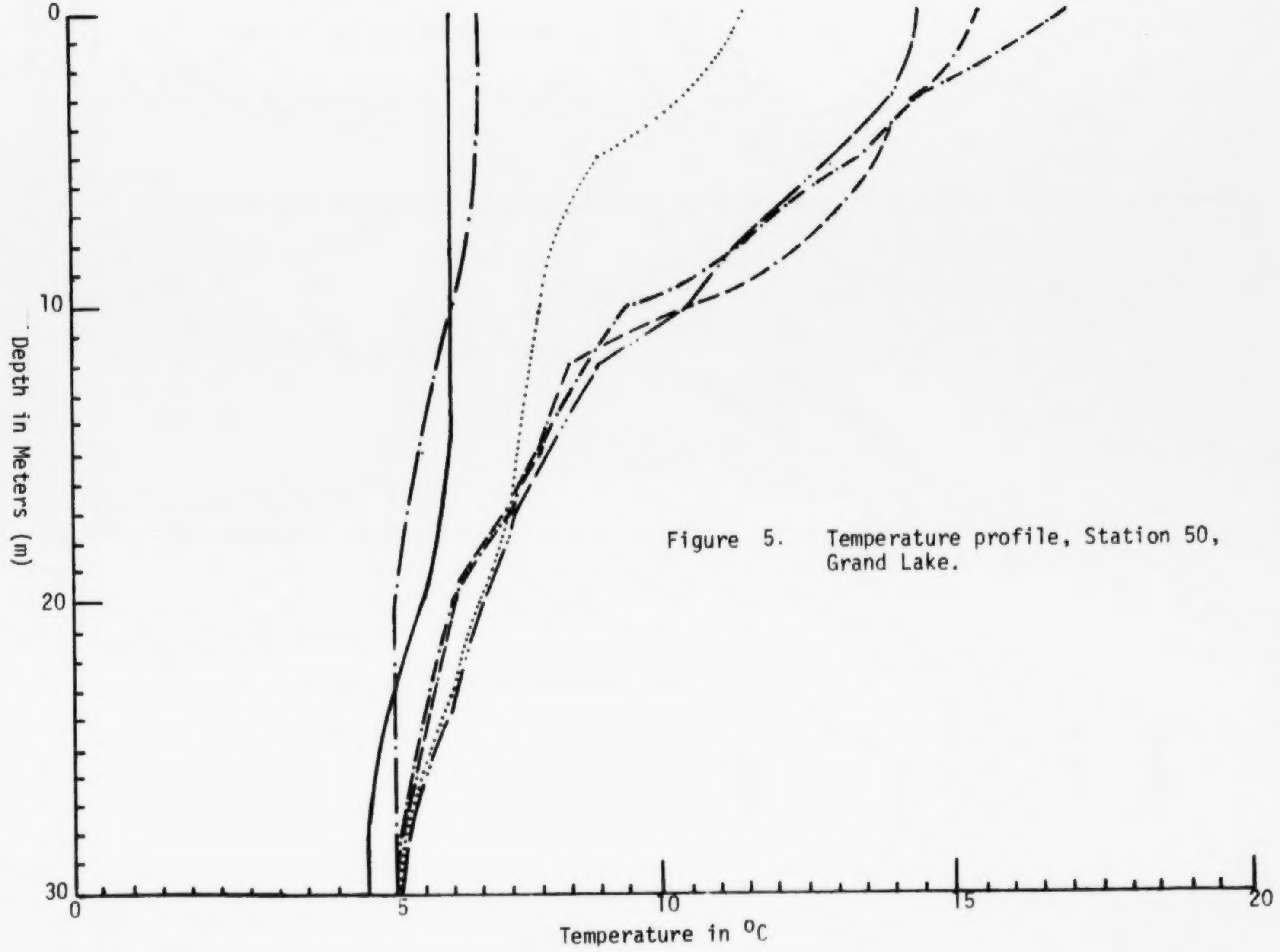

Figure 5. Temperature profile, Station 50, Grand Lake.

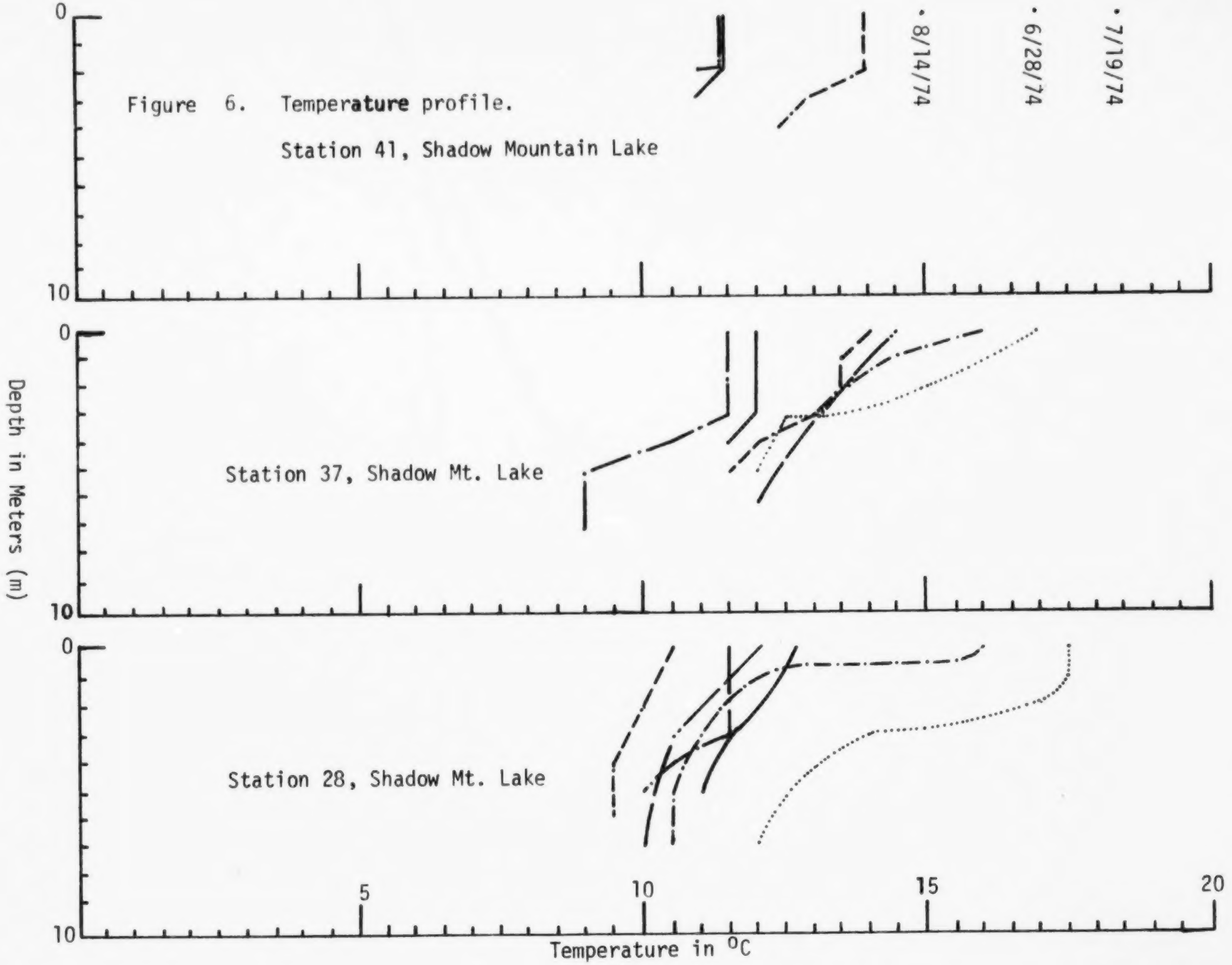

Figure 6. Temperature profile.

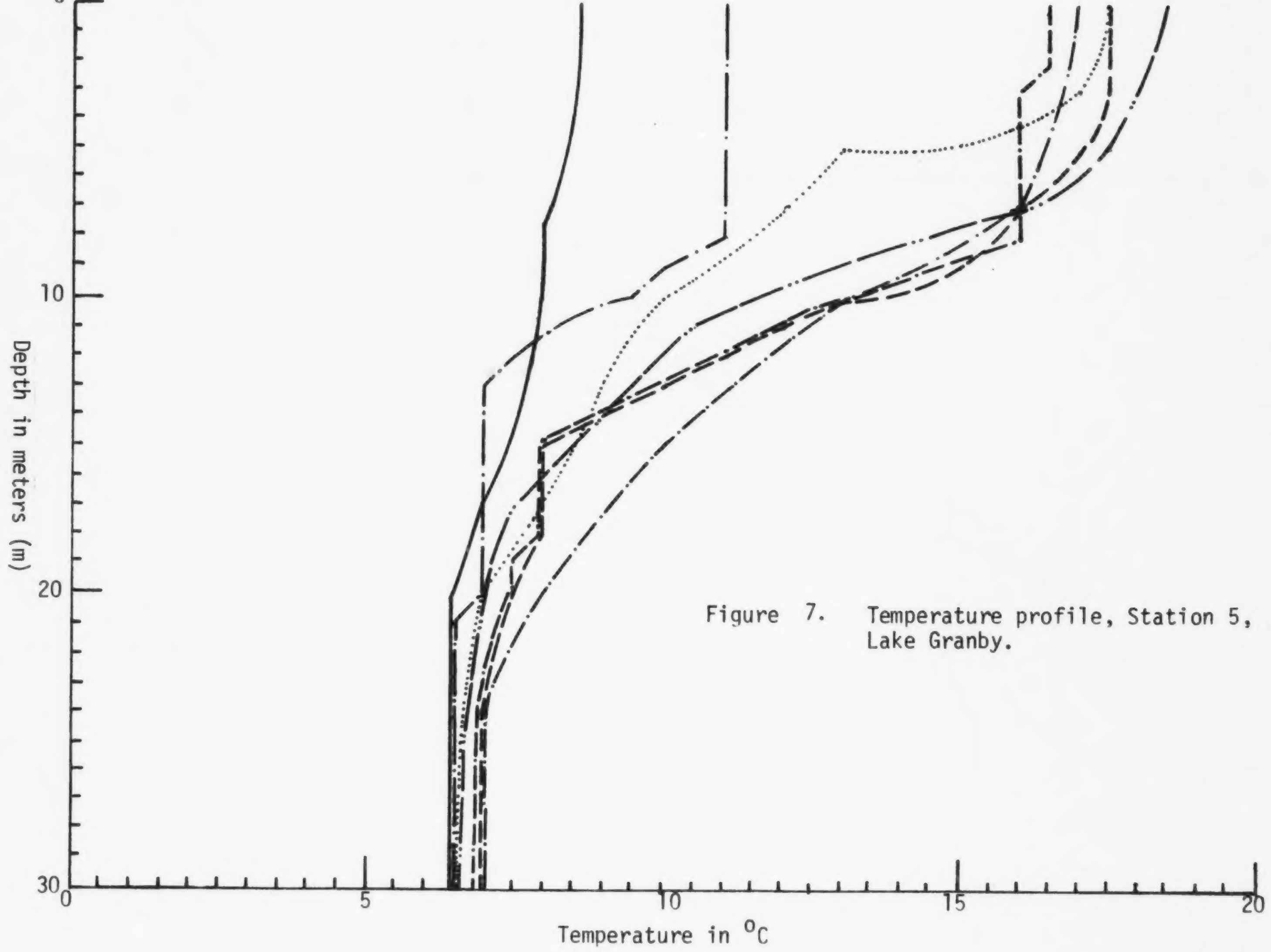

Figure 7. Temperature profile, Station 5, Lake Granby.

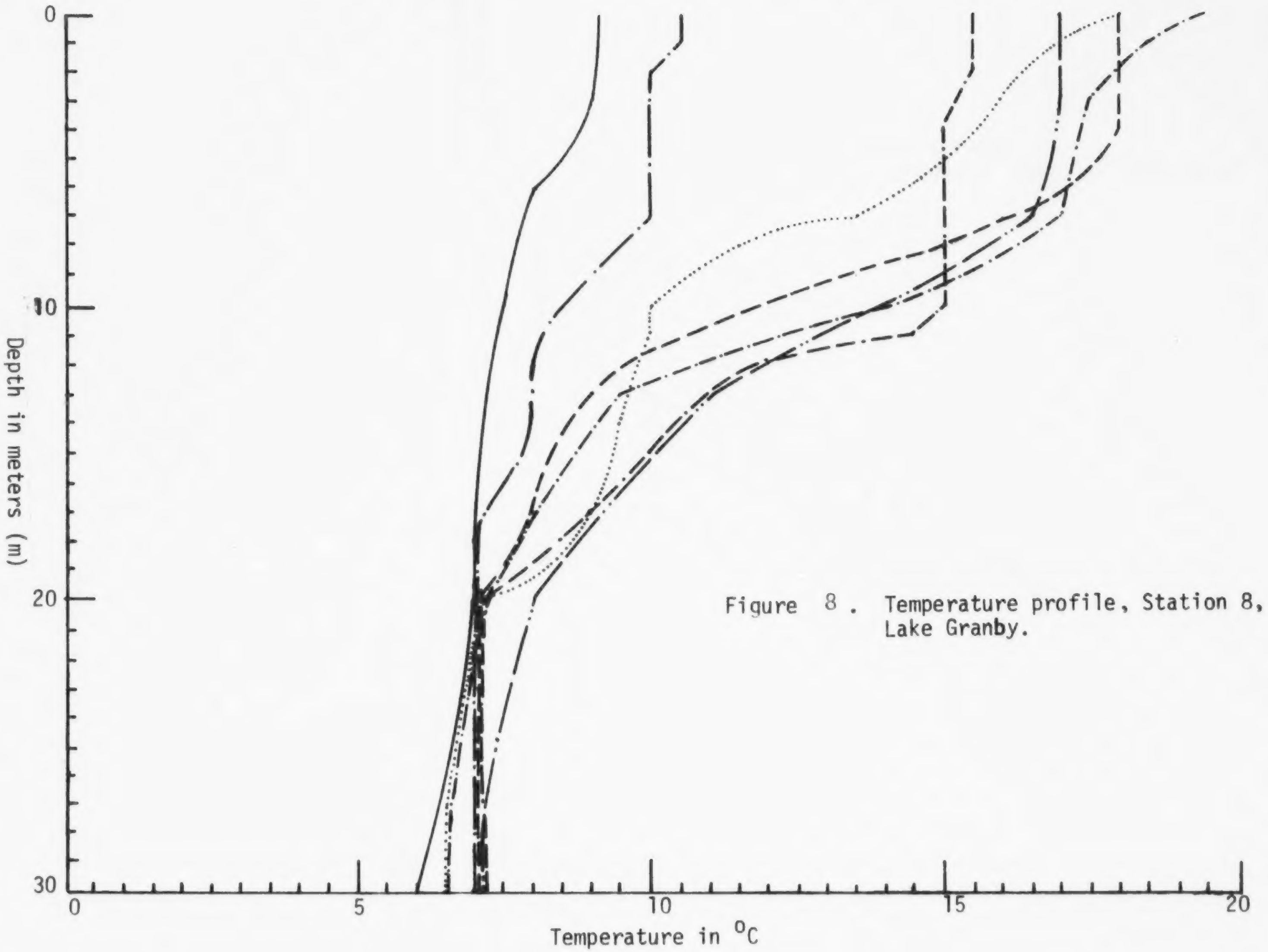

Figure 8. Temperature profile, Station 8, Lake Granby.

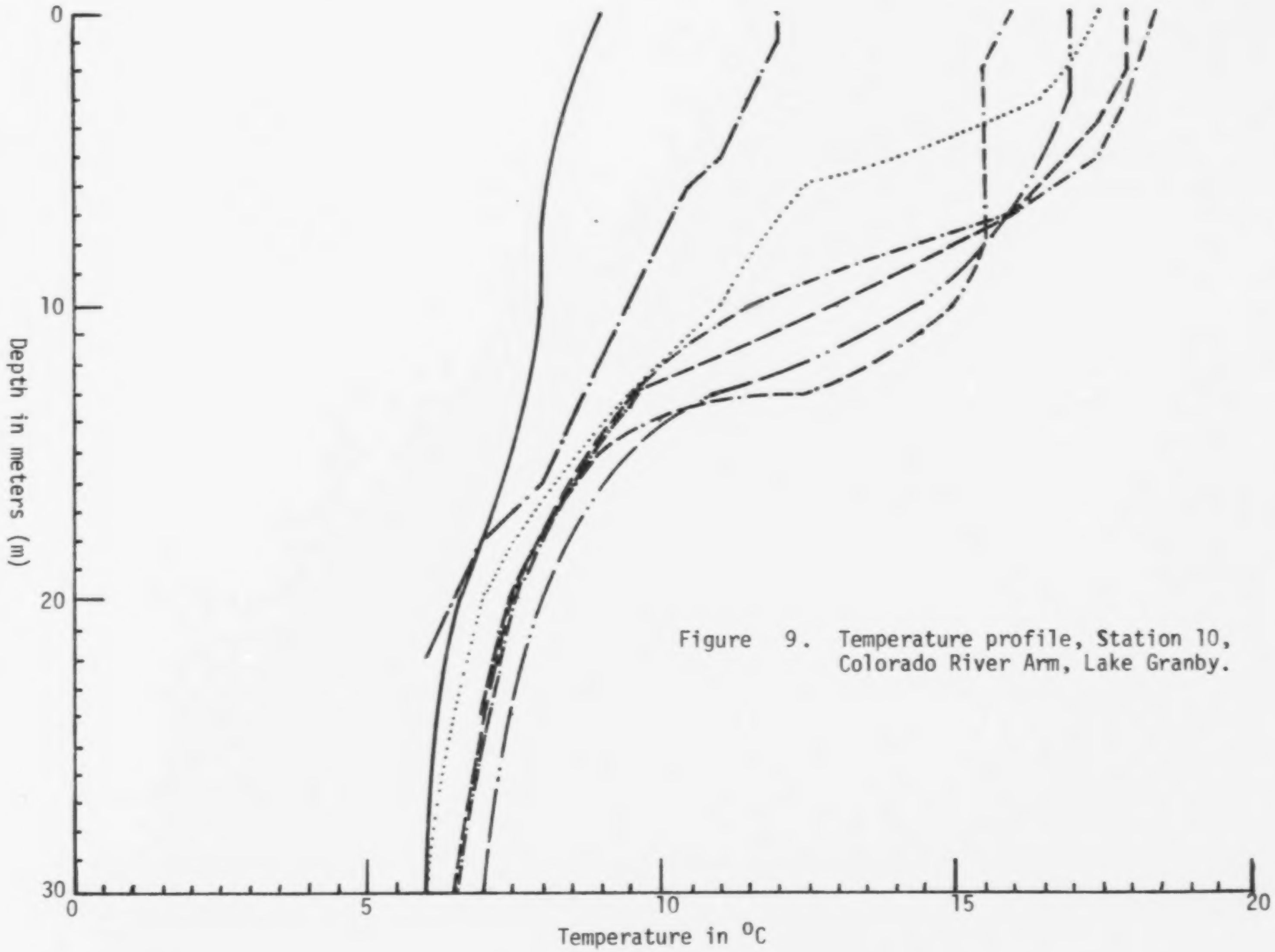

Figure 9. Temperature profile, Station 10, Colorado River Arm, Lake Granby.

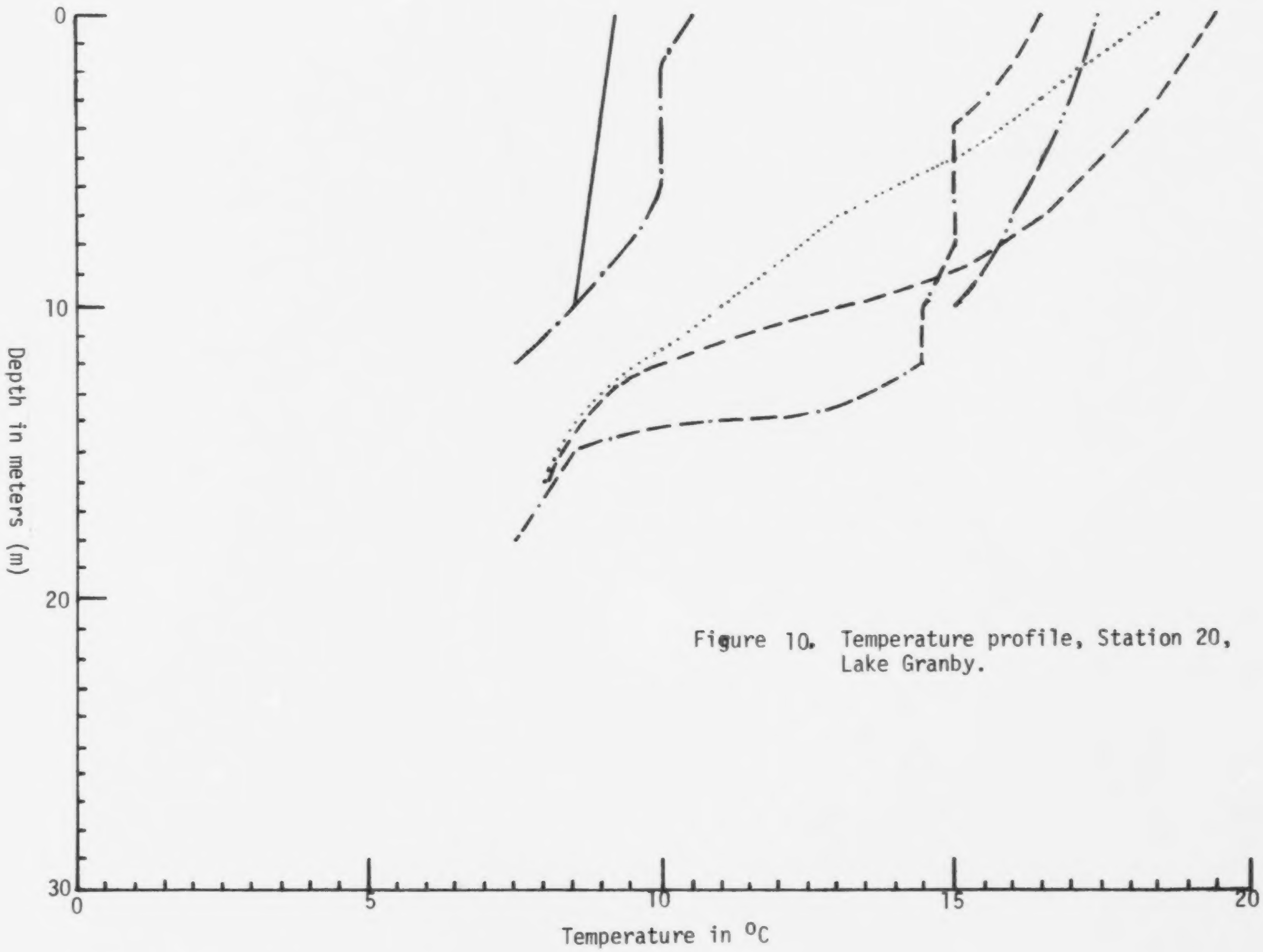

Figure 10. Temperature profile, Station 20, Lake Granby.

TABLE 21

pH VALUES IN THE THREE LAKES AND THE COLORADO RIVER

(Standard pH Units)

Location	5/30	6/7-19*	6/28	7/19	8/1	8/14	9/4-19*
Lake Granby							
Colorado River Arm (10)							
surface	7.5	7.7	7.8	-	7.5	7.3	7.9
mid	7.4/7.3	-	7.3/7.5	-	7.2/6.3	7.0/6.8	-
bottom	7.3	7.4	7.5	-	7.3	7.6	7.3
Middle (14)							
surface	7.7	8.2	8.3	-	8.3	7.1	7.6
mid	7.5/7.4	7.8/-	8.4/7.4	-	7.9/7.6	7.0/6.7	7.1/-
bottom	7.3	7.7	7.1	-	7.8	7.2	7.0
North (20)							
surface	7.8	8.1	8.2	-	8.5	8.3	7.6
mid	-	7.8/-	8.4/7.8	-	-	-/7.8	-
bottom	7.5	7.7	6.9	-	-	7.8	7.2
Arapahoe Arm (5)							
surface	7.5	7.9	8.4	-	7.6	7.0	7.8
mid	7.4/7.3	7.9/-	7.8/7.8	-	7.6/7.5	6.9/6.4	7.0/-
bottom	7.3	7.4	7.0	-	7.1	7.3	6.9
Shadow Mountain Lake							
North (41)							
surface	7.9	7.5	8.0	-	-	8.0	7.7
mid	-	-	-	-	-	-	-
bottom	-	7.3	-	-	-	-	-
Middle (37)							
surface	7.2	7.7	7.4	-	7.7	7.4	7.3
mid	7.2	-	7.5	-	-	-	-
bottom	7.3	7.4	7.5	-	-	7.7	7.2
South (28)							
surface	7.4	7.8	7.4	-	7.9	7.0	7.2
mid	7.6	-	7.4	-	7.8	-	-
bottom	7.3	7.5	7.4	-	7.8	8.1	7.3
Grand Lake							
Middle (50)							
surface	7.6	7.1	7.0	-	7.6	7.6	7.2
mid	7.2/7.1	7.1/-	7.0/7.1	-	7.2/7.5	6.9/6.5	6.9/-
bottom	7.2	7.0	7.4	-	7.4	7.6	6.7
Colorado River (58) Downstream of Granby	7.6	7.5	7.5	-	7.6	7.9	7.1

*Geometric Mean Value for 3-day sampling period.

TABLE 22

DISSOLVED OXYGEN CONCENTRATIONS IN THE THREE LAKES AND THE COLORADO RIVER

	Dissolved Oxygen Concentration (mg/l)						
Location	5/30	6/7-19*	6/28	7/19	8/1	8/14	9/4-19*
Lake Granby							
Colorado River Arm (10)							
surface	8.1	8.6	7.9	8.1	7.5	7.1	7.9
mid	8.3/8.1	-	7.8/7.9	6.4/6.1	7.2/6.3	7.0/6.1	-
bottom	7.9	7.7	6.8	6.1	5.1	5.3	4.7
Middle (14)							
surface	9.0	9.1	8.3	7.9	7.1	7.2	7.6
mid	9.0/8.7	8.8/-	7.9/7.4	6.7/6.6	6.8/5.8	7.0/6.0	6.0/-
bottom	8.7	7.6	7.1	6.4	6.2	5.6	5.0
North (20)							
surface	9.3	9.0	7.9	7.6	6.5	7.1	7.8
mid	-	8.3/-	7.9/7.9	6.6/5.9	-	-/7.0	-
bottom	9.0	8.3	6.9	6.1	-	6.5	7.3
Arapahoe Arm (5)							
surface	7.9	9.1	7.2	7.7	7.2	7.4	7.8
mid	9.0/8.9	9.1/-	7.9/7.9	7.3/6.5	5.5/7.2	7.0/5.4	5.7/-
bottom	8.4	7.9	7.9	7.3	6.1	5.6	4.8
Shadow Mountain Lake							
North (41)							
surface	8.2	8.5	7.5	7.3	-	-	8.0
mid	-	-	-	-	-	-	-
bottom	-	8.8	-	-	-	-	-
Middle (37)							
surface	8.1	8.4	7.9	7.4	8.0	7.6	7.9
mid	8.1	-	7.9	7.4	-	-	-
bottom	8.1	8.2	7.5	6.3	-	8.0	8.1
South (28)							
surface	8.1	8.4	7.5	7.3	8.2	7.4	6.6
mid	8.1	-	7.3	7.7	8.3	-	-
bottom	8.0	7.3	7.4	6.9	7.4	7.0	6.4
Grand Lake							
Middle (50)							
surface	8.3	9.1	8.1	7.9	8.3	8.1	8.2
mid	8.3/7.9	8.6/-	8.6/8.6	7.9/8.1	7.5/7.4	7.6/7.4	6.9/-
bottom	7.7	6.0	7.3	7.2	7.2	7.3	2.8
Colorado River (58) Downstream of Granby	9.2	9.2	7.7	10.0	9.2	9.1	9.1

*Mean value for 3-day sampling period.

the main body of any of the Three Lakes which exhibited extremely low dissolved oxygen concentrations in the hypolimnion.

In summary, dissolved oxygen concentrations reported here are generally slightly higher than those previously reported. However, there is insufficient data available to conclude that dissolved oxygen conditions in the Three Lakes have either improved or deteriorated since the earlier studies.

Primary Productivity

A study of the primary productivity rates in the Three Lakes was conducted in order to gain an insight into the present trophic status of the lakes and to compare existing rates with those previously reported. Primary productivity, as measured by the C^{14} method, gives an indication of the rates of carbon fixation by the primary producers. The C^{14} methodology is presently one of the best assessments of the effect of interactions of the physical, chemical, and biological factors which determine the actual fertility of any environment (Goldman, 1961).

Primary productivity studies were conducted on September 9, 10, 11, and 13, 1974, at a total of 14 stations. Water samples were collected with a Van Doren water sampler, placed in 300 ml light and dark bottles and inoculated with 1 ml of $NaHCO_3$ solution containing 4.4 μCi of C^{14} per ml. All samples were then re-suspended at the depth from which they were collected. At the end of a six hour period, the samples were retrieved, filtered through 0.45μ membrane filters and placed in a dessicator to await analysis at the EPA, Region VIII chemistry laboratory in Denver, Colorado. Prior to analysis each filter was placed in a counting vial and dissolved with 1.5 ml Diethyl Formamide. The counting vials were then filled with Cab-O-Sil plus 15 ml of toluene base scintillation solution. Each dissolved sample was then counted in a liquid scintillation counter.

Light penetration into the lake waters was measured with a submarine photometer and secchi disk. Incident light measurements were made with a Belfast recording pyrheliometer equipped with a 24-hour chart drive. The recorder was started before sunrise and allowed to run until after sunset. Alkalinity measurements were obtained at each sample location for use in computing total C values at the time of C^{14} primary productivity studies.

During this study, productivity rates for the Three Lakes were typical of mesotrophic to eutrophic waters (Committee on Water Quality Criteria, 1972). Primary productivity rates per m^2 for Grand Lake, Shadow Mountain Lake, and Lake Granby are listed in Table 23. Page 78 in Appendix A lists productivity rates in m^3 at selected depths. Values ranged from 8.1 mg $C/m^2/hr$ in Granby (Station 23) to 32.8 mg $C/m^2/hr$ in Grand Lake (Station 54). Essentially all of the primary productivity occurred in the upper six meters of the water column, a condition similar to that reported by Nelson (1971).

TABLE 23

PRIMARY PRODUCTIVITY RATES AND ILLUMINATION DEPTHS FOR THE THREE LAKES

Lake	Date	Station	Primary Productivity mgC/m^2/hr	Illumination Depth (meters)
Granby	9/13/74	2	18.0	4.8
		5	16.0	5.0
		8	19.2	5.5
		10	22.7	5.2
	9/11/74	14	20.8	5.0
		16	18.9	4.8
		20	16.0	4.6
		23	8.1	4.0
			Avg. 17.5	4.9
Shadow Mtn.	9/ 9/74	28	15.5	4.8
		33	20.0	4.0
		37	20.4	4.0
			Avg. 18.6	4.3
Grand	9/10/74	47	15.3	4.6
		50	20.5	5.5
		54	32.8	5.5
			Avg. 22.9	5.2

Table 24

Previously Reported Productivity Rates*

Compared to Present (1974) Rates

Lake	Date	Primary Productivity $mgC/m^2/hr.$	Illumination Depth (meters)
Granby	7/31/63[1]	39.0	4.8
	7/28/64[1]	40.0	6.1
	7/30/65[1]	14.0	5.8
	9/(11-13)/74[2]	17.5	4.9
Shadow Mtn.	7/30/63	51.0	3.9
	7/29/64	52.0	4.2
	7/29/65	24.0	4.4
	9/9/74	18.6	4.3
Grand Lake	7/30/63	43.0	4.0
	7/29/64	31.0	5.0
	7/29/65	12.0	7.2
	9/10/74	22.9	5.2

* Productivity rates as reported by Nelson (1971).

[1] Nelson (1971)

[2] EPA (1974)

The primary productivity rates presented here are similar to those reported by Nelson (1971) for July 1965, but are markedly lower than his values for 1963-64 (Table 24). It is important to recognize that the values shown as "previously reported productivity rates" should not be taken as absolute values of primary productivity for each lake in question. All of the reported values are from very limited sampling periods and may reflect either maximum, minimum, or mean primary productivity rates for the summer months. The primary productivity rates, however, do reflect the level of productivity at a given point in time and, when used in conjunction with other data (i.e. algal counts), can give useful insight into the present trophic status of the Three Lakes.

Aquatic Plant Survey

The presence of large quantities of aquatic plants in Shadow Mountain Lake has been documented in previous studies of the Three Lakes area (EPA, 1970; Kugrens and Paulsen, 1971). Extensive growths of aquatic plants, primarily Elodea sp., have physically inhibited boating and fishing in Shadow Mountain Lake and created objectionable odors during decay. Although a complete investigation of the aquatic plant growths was beyond the scope of this study, limited sampling was conducted at three different times during the summer of 1974 to determine the relative increase in growth.

At each sampling station, an average of three samples of aquatic plants were collected along transects extending from the shoreline out to the 4.6 m (15 ft) depth. Samples were collected using a Petersen dredge. Figures 11-13 show the relative increase in abundance during the summer. The general terms - sparse, moderate, and abundant - indicate the relative amounts of aquatic plants collected at each location.

Phytoplankton Survey

In order to determine the kinds and relative abundance of indigenous algal species in the Three Lakes, water samples for plankton analysis were collected seven times during the period from May to September 1974. Eight stations were sampled during each of the sampling periods.

Sampling station locations and dates of sampling are noted in Tables 25-32. All samples were collected at a depth of one meter, immediately preserved with 5% formalin, and stored in the dark until analysis. Prior to analysis, 50 ml of sample were allowed to settle for 2-3 days, after which a 10 ml aliquot was used for analysis. A portion of the aliquot was placed in a Sedgewick-Rafter cell and two strips counted for each sample, algal cell concentrations being reported as cells per milliliter. Filamentous or colonial algae were counted as a single unit rather than as individual cells. Results of the algal counts are shown in Tables 25-32. An 'x' indicates that the algal species was observed while scanning the sample but was not observed during the acutal strip counts.

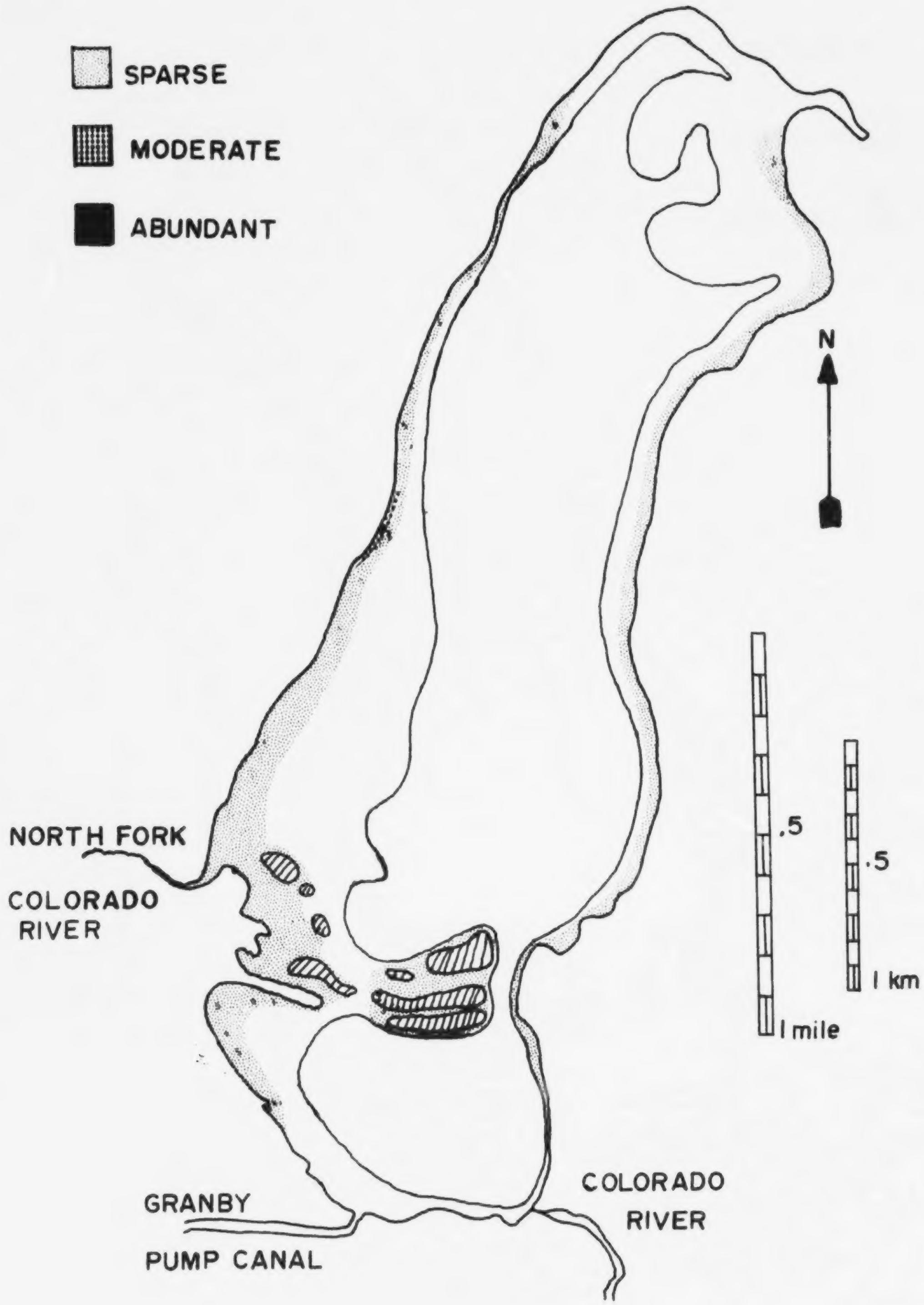
SPARSE
MODERATE
ABUNDANT
N
.5
1 mile
.5
1 km
NORTH FORK
COLORADO
RIVER
GRANBY
PUMP CANAL
COLORADO
RIVER

Figure 11. Aquatic Plant Survey, Shadow Mountain Lake, June 16, 1974.

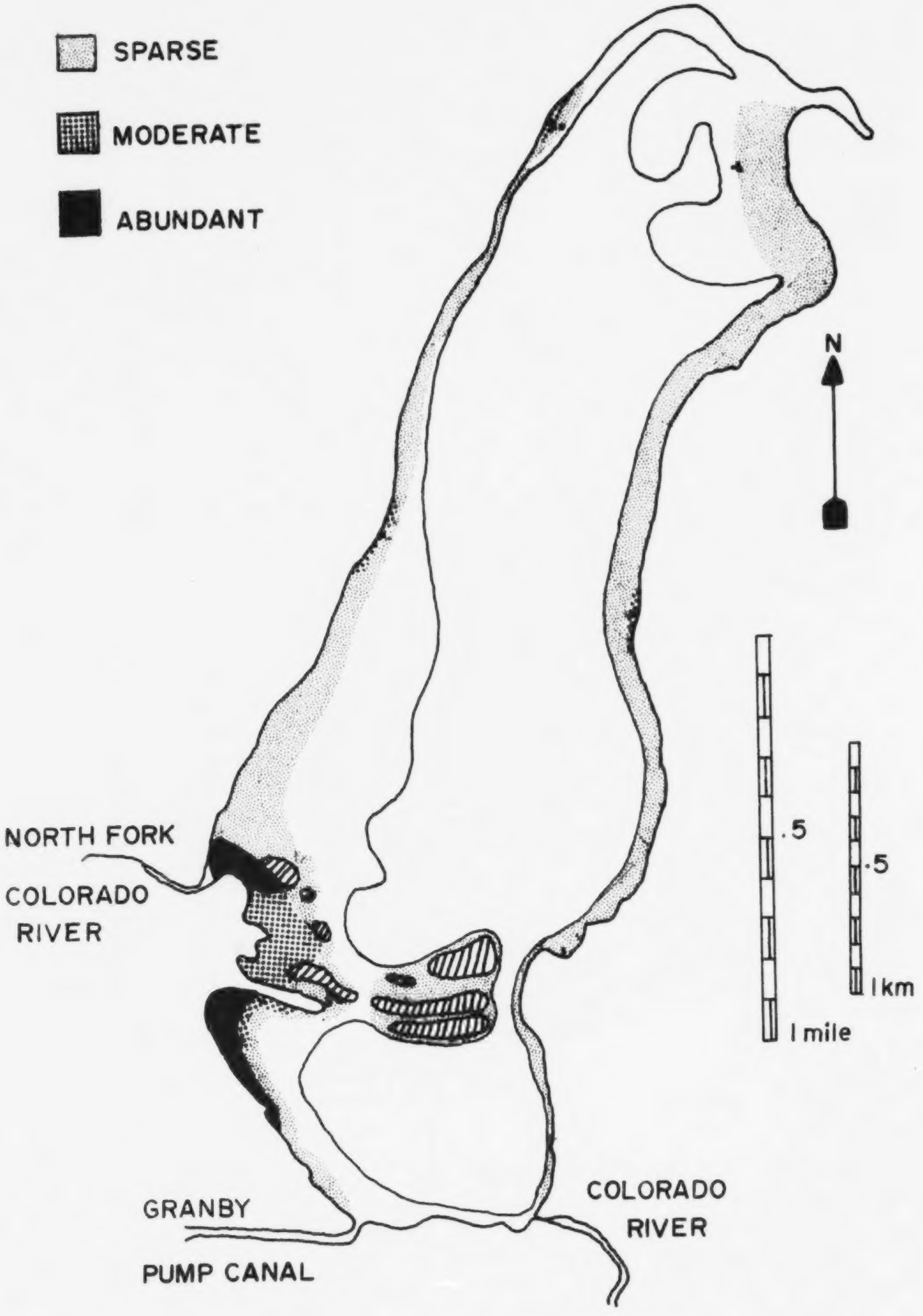
SPARSE
MODERATE
ABUNDANT
N
.5
.5
1 mile
1km
NORTH FORK
COLORADO
RIVER
GRANBY
PUMP CANAL
COLORADO
RIVER

Figure 12. Aquatic Plant Survey, Shadow Mountain Lake, July 17, 1974.

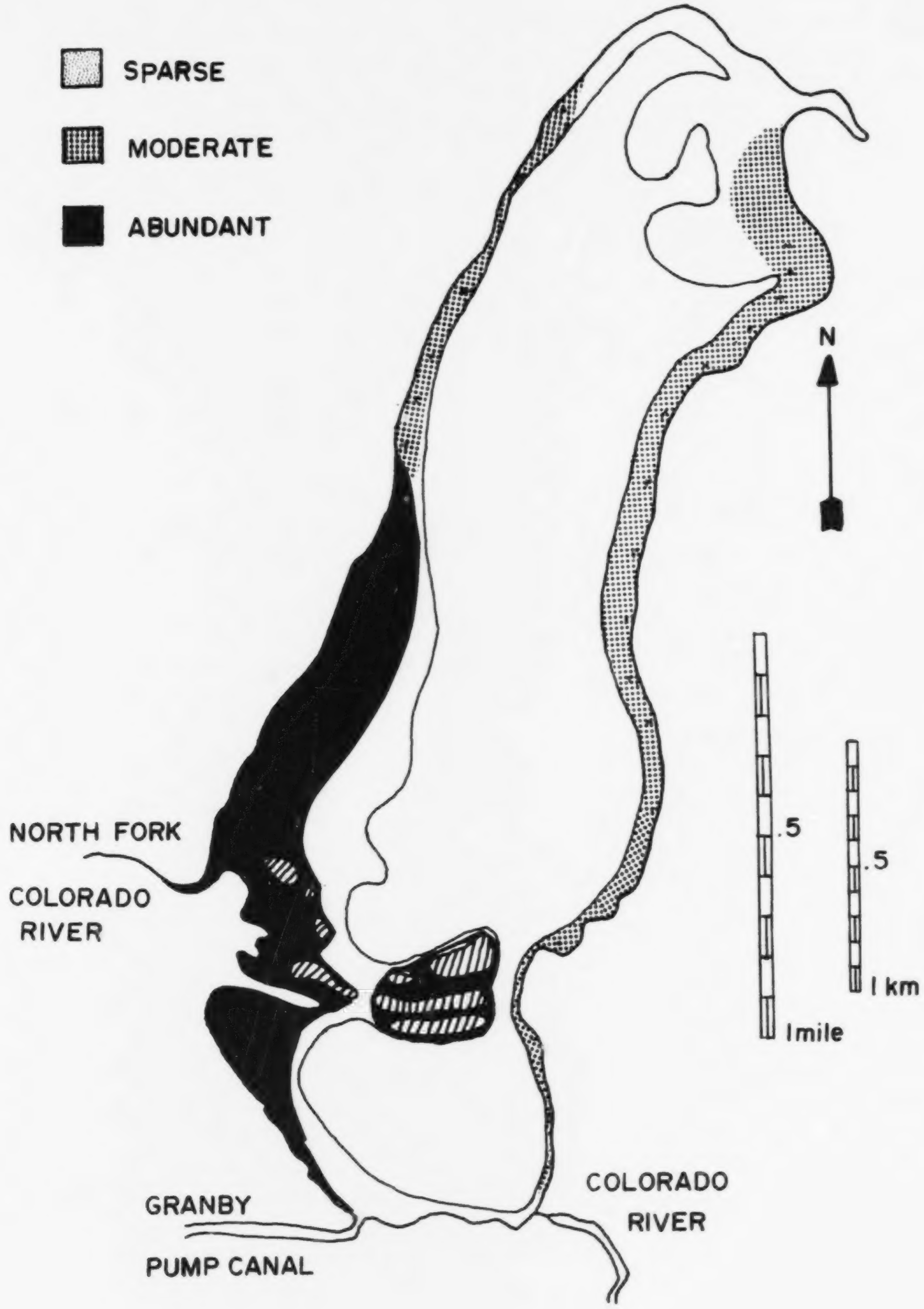
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Figure 13. Aquatic Plant Survey, Shadow Mountain Lake, September 17, 1974.

TABLE 25

PHYTOPLANKTON DATA FROM GRAND LAKE - MIDDLE (STATION 50)

	5/30	6/15	6/28	7/19	8/1	8/14	9/9
Bacillariophyta							
Gomphonema sp.	18	8					
Diatoma sp.	8	16	8				
Fragilaria sp.	8	8			8	16	x
Melosira sp.	48	56	24	40	x	16	x
Navicula sp.	8		16				
Cocconeis sp.	16						8
Stephanodiscus sp.	192		56			64	
Eunotia sp.			8				
Nitzschia sp.		72		16	x	x	8
Asterionella sp.				48	72	48	64
Cyclotella sp.				8			16
Gyrosigma sp.						x	
Pinnularia sp.		x					
Rhoicospenia sp.		16					
Unident. pennate	32						
Total cells/ml	330	176	112	150	80	144	96
Cyanophyta							
Anacystis sp.	32			8		8	x
Anabaena sp.		x			8		x
Lyngbya sp.			40				
Total cells/ml	32		40	8	8	8	
Chlorophyta							
Schroderia sp.		8		16	56		24
Volvulina sp.		x		8	x	8	
Dictyosphaerium sp.					8	8	32
Characium sp.					8		
Closterium sp.						8	
Cosmarium sp.						8	16
Scenedesmus sp.						x	
Single cell flag. green			40	56			
colonial green			32				
Volvox sp.				8			
Oocystis sp.							x
Spondylosium sp.							x
Total cells/ml		8	72	88	72	32	88
Chrysophyta							
Dinobryon sp.			8	16	24	x	
Total cells/ml			8	16	24	x	
Grand Total cells/ml	362	184	232	262	184	184	184

TABLE 26

PHYTOPLANKTON DATA FROM SHADOW MOUNTAIN LAKE
NORTH END (STATION 41)

	5/30	6/15	6/28	7/19	8/1*	8/14	9/9*
Bacillariophyta							
Stephanodiscus sp.	260	40		40		x	
Melosira sp.	192	176		16		56	
Asterionella sp.	48	64	56	8		72	
Synedra sp.	80	8				8	
Diatoma sp.	16	8					
Navicula sp.	40		32			x	
Tabellaria sp.	12			8		8	
Nitzschia sp.	72	184	112	8		96	
Cocconeis sp.	12	x	8			16	
Fragilaria sp.	20			16		96	
Cymbella sp.	4	40		8			
Gomphonema sp.	4						
Pinnularia sp.		x		8		x	
Caloneis sp.		8	8			32	
Amphora sp.				x			
Epithemia sp.						x	
Cyclotella sp.						8	
Total cells/ml	760	528	208	112		392	
Cyanophyta							
Anacystis sp.	44	x		8			
Oscillatoria sp.	4		8				
Anabaena sp.	4	x				8	
Lyngbya sp.		32	32				
Total cells/ml	52	32	32	8		8	
Chlcrophyta							
Scenedesmus sp.	8					x	
Trachelomonas sp.	16						
Closterium sp.	40		32				
Cosmarium sp.	4						
Dictyosphaerium sp.			8				
Volvulina sp.				8			
Schroderia sp.				8		x	
Elaktothrix sp.						24	
Ankistrodesmus sp.						x	
Unident. single cell	36		8				
Unident. single cell flag.	12		120	128			
Total cells/ml	116		168	144		24	
Chrysophyta							
Dinobryon sp.	48	x	40	8			
Total cells/ml	48		40	8			
Grand Total cells/ml	976	560	448	272		424	

*No sample taken.

TABLE 27

PHYTOPLANKTON DATA FROM SHADOW MOUNTAIN LAKE
MIDDLE (STATION 37)

	5/30	6/15	6/28	7/19	8/1	8/14	9/9
Bacillariophyta							
Stephanodiscus sp.	248	96	64	8	40	24	40
Melosira sp.	232	280	200	88	8	24	40
Synedra sp.	104	16	48	16			
Navicula sp.	88		40	16			16
Cocconeis sp.	48	8	8				24
Asterionella sp.	96	40	16		40	32	72
Nitzschia sp.	72	200	104	200	24		16
Fragilaria sp.	16	8	16	8	16		8
Diatoma sp.	8			48	8	24	
Cymbella sp.	8			8			
Caloneis sp.	16	8	8	8			
Closterium sp.			24				
Gomphonema sp.		x		32			
Cyclotella sp.		16			8	x	40
Pinnularia sp.		x					
Tabellaria sp.						x	
Diatoma sp.							8
Total cells/ml	936	672	528	432	144	104	232
Cyanophyta							
Anacystis sp.	40						
Anabaena sp.	8				104		
Lyngbya sp.		48	40				
Oscillatoria sp.			x	8			
Total cells/ml	48	48	40	8	104		
Chlorophyta							
Volvulina sp.		x				x	
Scenedesmus sp.				8	8	x	x
Dictyosphaerium sp.				8	8		
Schroderia sp.					16	x	24
Elaktothrix sp.						8	
Single cell			8				
Unident. colonial	24						
Spondylosium sp.							8
Micractinium sp.							16
Total cells/ml	24		8	16	32	8	48
Chrysophyta							
Dinobryon sp.	40		8	16	32	8	
Total cells/ml	40		8	16	32	8	
Grand Total cells/ml	1048	720	584	472	312	120	360

TABLE 28

PHYTOPLANKTON DATA FROM SHADOW MOUNTAIN LAKE
SOUTH END (STATION 28)

	5/30	6/15	6/28	7/19	8/1	8/14	9/9
Bacillariophyta							
Melosira sp.	216	152	64			40	32
Stephanodiscus sp.	176	88	40			16	48
Navicula sp.	36	16	32		x	8	8
Asterionella sp.	40	16	16	24	160	16	48
Stauroneis sp.	12						
Cymbella sp.	4	24		x			
Synedra sp.	144	16	8			8	
Fragilaria sp.	56	16			x	x	x
Nitzschia sp.	28	184	96		8	56	48
Gomphonema	8						
Tabellaria sp	32					8	
Cocconeis sp.	8	24	8			8	
Pinnularia sp.		8					
Caloneis sp.		16	24			x	
Diatoma sp.		8			x		
Cyclotella sp.				24	x		8
Total cells/ml	760	568	288	48	160	160	192
Cyanophyta							
Anacystis sp.	32	16					
Anabaena sp.		24		16	24		8
Lyngbya		48	8				x
Total cells/ml	32	88	8	16	24		8
Chlorophyta							
Closterium sp.	56	x	24				
Trachelomonas sp.	12						
Selenastrum sp.	4						
Pediastrum sp.	8						
Scenedesmus sp.	4						x
Schroderia sp.				16	x		24
Spondylosium sp.				x			8
Elaktothrix sp.						x	
Unident. unicell flag.	24		136		320		
Unicell w/ seate	12						
Dictosphaerium sp.							x
Volvulina sp.							x
Phacus sp.							x
Total cells/ml	120		160	16	320		32
Chrysophyta							
Dinobryon sp.	96	16	24				
Total Cells/ml	96	16	24				
Grand Total cells/ml	1008	672	480	80	504	160	232

TABLE 29

PHYTOPLANKTON DATA FROM LAKE GRANBY
ARAPAHOE ARM (STATION 5)

	5/30	6/15	6/28	7/19	8/1	8/14	9/9
Bacillariophyta							
Stephanodiscus sp.	240	x	8	16	8		
Asterionella sp.	16	32	x	232	16	16	
Synedra sp.	16						
Melosira sp.	16	24	8		8		16
Navicula sp.	32	8	16				
Fragilaria sp.		x			80	48	
Diatoma sp.		x					
Nitzschia sp.		96	40				24
Tabellaria sp.		8					
Cocconeis sp.						8	
Cyclotella sp.				8			16
Total cells/ml	320	168	72	256	112	72	56
Cyanophyta							
Anacystis sp.	192		168	16	8	8	8
Lyngbya sp.		24	x				
Anabaena sp.		x				8	x
Unident. colonial			40				
Total cells/ml	192	24	208	16	8	16	8
Chlorophyta							
Spondylosium sp.			x				
Volvulina sp.				8	16	x	8
Eudorina sp.				8			
Dictyosphaerium sp.				8		x	x
Cosmarium sp.					16	16	x
Schroderia sp.					56		
Pediastrum sp.							x
Oocystis sp.							x
Total cells/ml				32	88	16	8
Chrysophyta							
Dinobryon sp.		16	x	16	16	x	
Total cells/ml		16		16	16		
Grand Total cells/ml	512	208	280	320	224	104	72

TABLE 30

PHYTOPLANKTON DATA FROM LAKE GRANBY
MIDDLE (STATION 14)

	5/30	6/15	6/28	7/19	8/1	8/14	9/9
Bacillariophyta							
Stephanodiscus sp.	96	x		8			32
Melosira sp.	128	16	48				8
Synedra sp.		16	8				
Navicula sp.		16	32				
Nitzschia sp.		184	112		x		16
Diatoma sp.		16	x				
Tabellaria sp.		32	8				
Asterionella sp.		32	16	96			
Fragilaria sp.			x	8	80	16	
Cyclotella sp.			8	8		16	16
Cymbella sp.		24			16		
Cocconeis sp.						8	x
Amphora sp.		x					
Total cells/ml	224	312	232	120	96	40	72
Cyanophyta							
Anacystis sp.	144		496	40	8	2	24
Lyngbya sp.		32	8				
Anabaena sp.					8	x	x
Unident. colonial			64				
Total cells/ml	144	32	568	40	16	2	24
Chlorophyta							
Ankistrodesmus sp.	16						
Cosmarium sp.	16			16	32	8	x
Volvox sp.	x						
Dictyosphaerium sp.			x	8	16		8
Volvulina sp.			8	8	8	x	x
Pandorina sp.					8		
Starastrum sp.					x	8	8
Schroderia sp.					16	x	
Elaktothrix sp.					x		
Golenkinia sp.							x
Phacus sp.							x
Trachelomonas sp.							x
Total cells/ml	32		8	32	80	16	16
Chrysophyta							
Dinobryon sp.		48	16		8		
Total cells/ml		48	16		8		
Grand Total cells/ml	400	392	824	192	200	58	112

TABLE 31

PHYTOPLANKTON DATA FROM LAKE GRANBY
COLORADO RIVER ARM (STATION 10)

	5/30	6/15	6/28	7/19	8/1	8/14	9/9
Bacillariophyta							
Stephanodiscus sp.	132	72	24	8	8	24	x
Melosira sp.	160	256	56				88
Fragilaria sp.	12	32	x		80	16	16
Synedra sp.	104	8	16				
Tabellaria sp.	8	8					
Nitzschia sp.	16	432	64		8		
Cymbella sp.	8						
Gomphonema sp.	4	8	8				
Navicula sp.	20		16		8		x
Asterionella sp.	8	48	32	112	32		
Amphora sp.		16				x	
Pinnularia sp.		x					
Diatoma sp.			8				
Actinella sp.			x				
Cyclotella sp.						8	8
Cocconeis sp.							x
Total cells/ml	472	880	288	120	136	48	112
Cyanophyta							
Anacystis sp.	144		48	32		16	8
Lyngbya sp.		136	24				
Anabaena sp.						x	x
Unident. colonial			32			16	
Total cells/ml	144	136	104	32		32	8
Chlorophyta							
Cosmarium sp.	4				24		16
Scenedesmus sp.		x					
Closterium sp.			8				
Dictyosphearium sp.				8		8	32
Volvulina sp.					8		
Schroderia sp.					8	x	x
Pediastrum sp.					8		
Elaktothrix sp.					x		
Spondylosium sp.						x	x
Pandorina sp.						x	
Oocystis sp.						x	
Unident. flag.	36						
Total cells/ml	40		8	8	56	8	48
Chrysophyta							
Dinobryon sp.		48	32				
Total cells/ml		48	32				
Grand Total cells/ml	656	1064	432	160	192	88	168

TABLE 32

PHYTOPLANKTON DATA FROM LAKE GRANBY
NORTH END (STATION 20)

	5/30	6/15	6/28	7/19	8/1	8/14	9/9
Bacillariophyta							
Stephanodiscus sp.	64	x	8	8	8		
Melosira sp.	48	144	8			8	x
Asterionella sp.	48	16	x	200	16	8	
Navicula sp.	32	8	24				x
Fragilaria sp.	x	x		x	8	40	
Cyclotella sp.		24		88		16	40
Nitzshica sp.		208	24	8	40	16	8
Cymbella sp.		24					
Synedra sp.		8			x		
Pinnularia sp.		8					
Caloneis sp.		8					
Cocconeis sp.			16				16
Gomphonema sp.			x				
Actinella sp.			x				
Diatoma sp.					x		
Total cells/ml	192	448	80	304	72	88	64
Cyanophyta							
Anacystis sp.	160		224	48			
Lyngbya sp.		32					
Anabaena sp.		x			8		
Total cells/ml	160	32	224	48	8		
Chlorophyta							
Volvox sp.	x						
Spirulina sp.			x				
Dictyosphaerium sp.				48			x
Volvulina sp.					8		x
Cosmarium sp.					24		
Schroderia sp.					8	8	
Micractinium sp.						x	
Single cell			8				
Unident. single cell flag.			8				
Total cells/ml			16	48	40	8	
Chrysophyta							
Dinobryon sp.		8	8				
Total cells/ml		8	8				
Grand Total cells/ml	352	488	328	400	120	96	64

The algal data presented show relatively low total cell counts for each lake with the highest counts observed during the spring and early summer and the lowest counts noted in the late summer and fall. Grand Lake consistently exhibited the lowest cell counts, while Shadow Mountain Lake exhibited the highest. The higher algal counts noted during the spring and early summer were due to increases in diatoms. With increasing water temperatures, diatom concentrations gradually decreased while green algal concentrations increased. Although green algal concentrations gradually increased during the summer, cell counts of green algae were consistently low and represented only a small percentage of the total cell count.

Bluegreen algae were generally found in low concentrations thoughout the entire duration of the study. Station 14 in Granby Lake, however, had a maximum bluegreen algal count of 568 cells/ml on 6/28/76. The major bluegreen algal specie observed during the study was Anacystis sp., while Anabena sp. and Lyngbya sp. were periodically reported. In contrast to previous reports (Prescott, 1955; EPA, 1970; Kugrens and Paulsen, 1972), Aphanizomenon sp. was not observed at any time during the study period. Aphanizomenon sp. had been reported in high concentrations.

Due to differences in time of sampling, sampling location, and sampling methods, comparison of the results from this survey with previously reported data is possible only on a generalized basis. The algal data reported here are similar to some previously reported values but markedly different from others. The spring and early summer algal counts from this survey were markedly higher than values reported by EPA (1970) and Kugrens and Paulsen (1972) but lower than values reported by Pennak (1955) for the same time of year sampling period. Algal counts from the mid-summer and fall sampling period were only slightly higher than corresponding values reported by EPA (1970) and Kugrens and Paulsen (1972). Additionally, the present study found consistently lower algal counts in Grand Lake than were previously reported by Prescott (1955).

Although only a limited number of phytoplankton samples were collected during this study, the data obtained is felt to be representative of the pelagic phytoplankton populations in the Three Lakes at the time of sampling. When compared with data from previous reports, the algal data presented here, aside from the lack of Aphanizomenon sp., do not show either marked increases in total cell count or shifts in the species composition.

Algal Growth Potential of the Three Lakes - A Laboratory Study

In order to investigate the possibility of accelerated eutrophication and assess the impact of nutrient loading on the productivity of Grand Lake, Shadow Mountain Lake, and Lake Granby, algal assays were initiated to determine the algal growth potential at present nutrient levels in the Three Lakes. An additional algal assay was conducted on the Colorado River at the outlet of Lake Granby to determine the algal growth potential of water leaving the Three Lakes system.

Methods

Water was collected from one station on Grand Lake (50), Shadow Mountain Lake (37), and Lake Granby (14) and from the Colorado River below Lake Granby on May 30, 1974. All water samples were collected approximately one meter below the surface and placed in plastic "cubi-containers". Water samples for nutrient analysis were also collected at the same time and were immediately preserved with 4 ml $HgCl_2$/liter. All samples were refrigerated during transportation to the laboratory. The algal assay test water was filtered through a 0.45μ membrane filter and then frozen until each assay was conducted. Results of the nutrient analyses are shown in Table 33-37.

Periodically, throughout the summer months, nutrient samples were collected at selected sampling points in the Three Lakes and the Colorado River. Although the sampling was not as frequent, and the stations sampled not as numerous as desired for a comprehensive comparison of the Three Lakes, it was felt that periodic sampling would give a generalized insight into possible nutrient stratification and cycling within each of the bodies of water. As discussed earlier, dissolved oxygen, temperature, and pH were also measured during each sampling period.

All algal assays were conducted following the procedures outlined in Algal Assay Procedure, Bottle Test (EPA, 1971). *Selenastrum capricornutum* Printz was used as the test alga. Assays were conducted in 250 ml wide mouth Erlenmeyer flasks, each flask containing 100 ml total volume of culture with four replicates per test concentration. Test cultures were inoculated from two week old stock cultures. All flasks were incubated for seven days in a constant temperature water bath at 24 ± 0.5°C. Compressed air was bubbled through each culture at a rate of 500 ml per minute to maintain a pH of 8.5 or less and prevent possible carbon limitation. All flasks were illuminated with cool-white fluroescent lighting of 400 ft-c (4303 lux).

Additions to the lake water of phosphorus (as K_2HPO_4) and nitrogen (as Na_2NO_3) were made singly or in combination of the two nutrients at concentrations (mg/l) of: 0.005 P, 0.01 P, 0.05 P, 0.01 N, 0.05 N, 0.1 N, 0.005 P + 0.01 N, 0.005 P + 0.05 N, 0.005 P + 0.1 N, 0.01 P + 0.01 N, 0.01 P + 0.05 N, 0.01 P + 0.1 N, 0.05 P + 0.01 N, 0.05 P + 0.05 N, 0.05 P + 0.1 N. Water from each station, inoculated with the test algae but no nutrients, was used as each respective control.

Algal growth was monitored using a Turner Model 111 Fluorometer to determine the chlorophyll *a* concentrations following each day of incubation. The fluorometer was calibrated for chlorophyll analysis using the methods outlined by Strickland and Parsons (1968). Fluorometric readings were then converted to dry weights using conversion factors established for water from each sampling location.

Figure 14 illustrates the growth responses of S. *capricornutum* to nutrient addition to the water taken from Grand Lake, Shadow Mountain, Lake Granby, and the Colorado River, the outflow of Lake Granby. Results from the four algal assays are expressed as maximum standing crop in mg dry

TABLE 33

CONCENTRATION OF AMMONIA NITROGEN IN THE THREE LAKES AND THE COLORADO RIVER

Location	5/30	6/7-19	6/28	7/19	8/1	8/14	9/4-19
Lake Granby							
Colorado River Arm (10)							
surface	0.007	<0.003	0.009	0.013	0.012	0.001	0.009
mid	0.013	-	0.009	0.006	0.010	0.007	-
bottom	0.014	0.023	0.023	0.005	0.001	0.008	0.015
Middle (14)							
surface	0.005	0.002	0.026	0.077	0.005	0.003	0.017
mid	0.007	<0.002	0.011	0.010	0.010	0.006	0.018
bottom	0.013	0.015	0.029	0.025	0.009	0.001	0.022
North (20)							
surface	0.008	<0.002	0.006	0.016	0.006	0.005	0.018
mid	-	<0.002	0.005	0.022	-	0.003	-
bottom	0.006	0.006	0.009	0.011	-	0.016	0.018
Arapahoe Arm (5)							
surface	0.002	<0.002	0.004	0.012	0.004	0.012	0.008
mid	0.007	-	0.004	0.009	0.005	0.009	0.016
bottom	0.013	0.002	0.030	0.007	0.007	0.012	0.019
Shadow Mountain Lake							
North (41)							
surface	0.011	<0.002	0.008	0.008	-	0.006	0.028
mid	-	-	-	-	-	-	-
bottom	-	<0.002	-	-	-	-	-
Middle (37)							
surface	0.007	<0.002	0.020	0.005	0.001	0.005	0.027
mid	-	-	-	-	-	-	-
bottom	0.004	<0.002	0.009	0.008	-	0.010	0.027
South (28)							
surface	0.005	<0.002	0.008	0.008	0.001	0.006	0.026
mid	-	-	-	-	-	-	-
bottom	0.005	0.004	0.008	0.026	0.001	0.013	0.027
Grand Lake							
Middle (50)							
surface	0.006	<0.002	0.009	0.014	0.001	0.011	0.031
mid	0.006	0.002	0.008	0.013	0.003	0.011	0.031
bottom	0.018	0.018	0.011	0.006	0.004	0.004	0.058
Colorado River							
Below Lake Granby	0.015	0.005	0.013	0.023	0.015	0.011	0.019

All values reported in mg/l as N.

TABLE 34

CONCENTRATIONS OF TOTAL KJELDAHL NITROGEN IN THE THREE LAKES AND THE COLORADO RIVER

Location	5/30	6/7-19	6/28	7/19	8/1	8/14	9/4-19
Lake Granby							
Colorado River Arm (10)							
surface	0.21	0.15	0.22	.41	.36	.16	0.28
mid	0.20	-	0.19	.22	.16	.12	-
bottom	0.24	0.16	0.18	.23	.16	.13	0.25
Middle (14)							
surface	0.28	0.31	0.24	.54	.19	.14	0.40
mid	0.16	0.27	0.19	.24	.16	.12	0.45
bottom	0.24	0.28	0.19	.22	.16	.09	0.67
North (20)							
surface	0.31	0.24	0.26	.39	.26	.26	0.34
mid	-	0.27	0.22	.22	-	.24	-
bottom	0.20	0.35	0.27	.28	-	.17	0.66
Arapahoe Arm (5)							
surface	0.20	0.29	0.17	.28	.26	.21	0.26
mid	0.22	-	0.26	.25	.20	.10	0.22
bottom	0.29	0.31	0.24	.21	.10	.09	0.24
Shadow Mountain Lake							
North (41)							
surface	0.26	0.23	0.18	.41	-	.34	0.35
mid	-	-	-	-	-	-	-
bottom	-	0.42	-	-	-	-	-
Middle (37)							
surface	0.24	0.32	0.25	.53	.30	.20	0.24
mid	-	-	-	-	-	-	-
bottom	0.24	0.26	0.23	.31	-	.28	0.29
South (28)							
surface	0.36	0.28	0.21	.32	.36	.16	0.18
mid	-	-	-	-	.30	-	-
bottom	0.26	1.60	0.20	.26	.24	.12	0.22
Grand Lake							
Middle (50)							
surface	0.23	0.48	0.14	.36	.34	.34	0.30
mid	0.24	0.46	0.14	.22	.22	.10	0.23
bottom	0.18	0.48	0.13	.22	.25	.14	0.25
Colorado River							
Below Lake Granby	0.26	0.29	0.26	.44	-	.15	0.34

All values reported in mg/l as N.

TABLE 35

CONCENTRATIONS OF NITRITE AND NITRATE NITROGEN IN THE THREE LAKES AND THE COLORADO RIVER

Location	5/30	6/7-19	6/28	7/19	8/1	8/14	9/4-19
Lake Granby							
Colorado River Arm (10)							
surface	0.001	0.003	0.001	0.001	0.004	0.003	0.002
mid	0.050	-	0.001	0.014	0.016	0.026	-
bottom	0.066	<0.061	0.050	0.068	0.094	0.100	0.135
Middle (14)							
surface	0.024	<0.001	0.001	0.002	0.001	0.001	0.001
mid	0.049	0.002	0.001	0.001	0.006	0.005	0.009
bottom	0.065	0.060	0.063	0.078	0.095	0.100	0.106
North (20)							
surface	0.009	0.001	0.001	0.002	0.002	0.001	0.003
middle	-	0.020	0.001	0.009	-	0.001	-
bottom	0.013	0.025	0.022	0.023	-	0.003	0.003
Arapahoe (5)							
surface	0.023	0.001	0.001	0.001	0.001	0.001	0.002
mid	0.020	-	0.001	0.002	0.001	0.017	0.004
bottom	0.070	0.001	0.067	0.076	0.058	0.109	0.095
Shadow Mountain Lake							
North (41)							
surface	0.001	0.009	0.001	0.001	-	0.001	<0.001
mid	-	-	-	-	-	-	-
bottom	-	0.022	-	-	-	-	-
Middle (37)							
surface	0.001	<0.001	0.001	0.001	0.001	0.002	0.001
mid	-	-	-	-	-	-	-
bottom	0.001	0.019	0.001	0.003	-	0.004	<0.001
South (28)							
surface	0.001	0.001	0.001	0.001	0.003	0.032	0.028
mid	-	-	-	-	-	-	-
bottom	0.001 0.	0.001	0.001	0.022	0.035	0.047	0.053
Grand Lake							
Middle (50)							
surface	0.065	0.025	0.011	0.001	0.005	0.001	0.001
mid	0.068	0.039	0.018	0.011	0.005	0.011	0.024
bottom	0.078	0.092	0.072	0.067	0.088	0.085	0.253
Colorado River Below Lake Granby	0.064	0.065	0.003	0.033	0.005	0.044	0.043

All values reported in mg/l as N.

TABLE 36

CONCENTRATIONS OF TOTAL PHOSPHATE IN THE THREE LAKES AND THE COLORADO RIVER

Location	5/30	6/7-19	6/28	7/19	8/1	8/14	9/4-19
Lake Granby							
Colorado River Arm (10)							
surface	0.020	0.010	0.011	0.016	0.012	.012	0.013
mid	0.031	-	0.014	0.009	0.013	.010	-
bottom	0.025	0.015	0.016	0.009	0.015	.011	0.034
Middle (14)							
surface	0.022	0.013	0.009	0.009	0.009	.011	0.009
mid	0.014	0.014	0.016	0.010	0.009	.011	0.009
bottom	0.013	0.026	0.012	0.013	0.013	.013	0.013
North (20)							
surface	0.020	0.012	0.009	0.011	0.010	.014	0.010
mid	-	0.016	0.017	0.011	-	.017	-
bottom	0.018	0.027	0.012	0.011	-	.017	0.015
Arapahoe Arm (5)							
surface	0.014	0.008	0.010	0.021	0.010	.012	0.015
mid	0.015	-	0.015	0.009	0.012	.010	0.013
bottom	0.019	0.014	0.041	0.010	0.010	.011	0.021
Shadow Mountain Lake							
North (41)							
surface	0.020	0.017	0.014	0.019	-	0.025	0.016
mid	-	-	-	-	-	-	-
bottom	-	0.040	-	-	-	-	-
Middle (37)							
surface	0.083	0.018	0.030	0.023	0.015	0.016	0.021
mid	-	-	-	-	-	-	-
bottom	0.022	0.019	0.018	0.013	-	0.023	0.006
South (28)							
surface	0.026	0.033	0.013	0.009	0.014	0.015	0.016
mid	-	-	-	-	0.018	-	-
bottom	0.026	0.240	0.015	0.011	0.013	0.014	0.019
Grand Lake							
Middle (50)							
surface	0.020	0.006	0.006	0.009	0.014	0.026	0.004
mid	0.020	0.008	0.007	0.006	0.012	0.007	0.001
bottom	0.011	0.009	0.007	0.005	0.009	0.007	0.001
Colorado River Below Lake Granby	0.024	0.010	0.022	0.011	0.011	0.008	0.026

All values reported in mg/l as P.

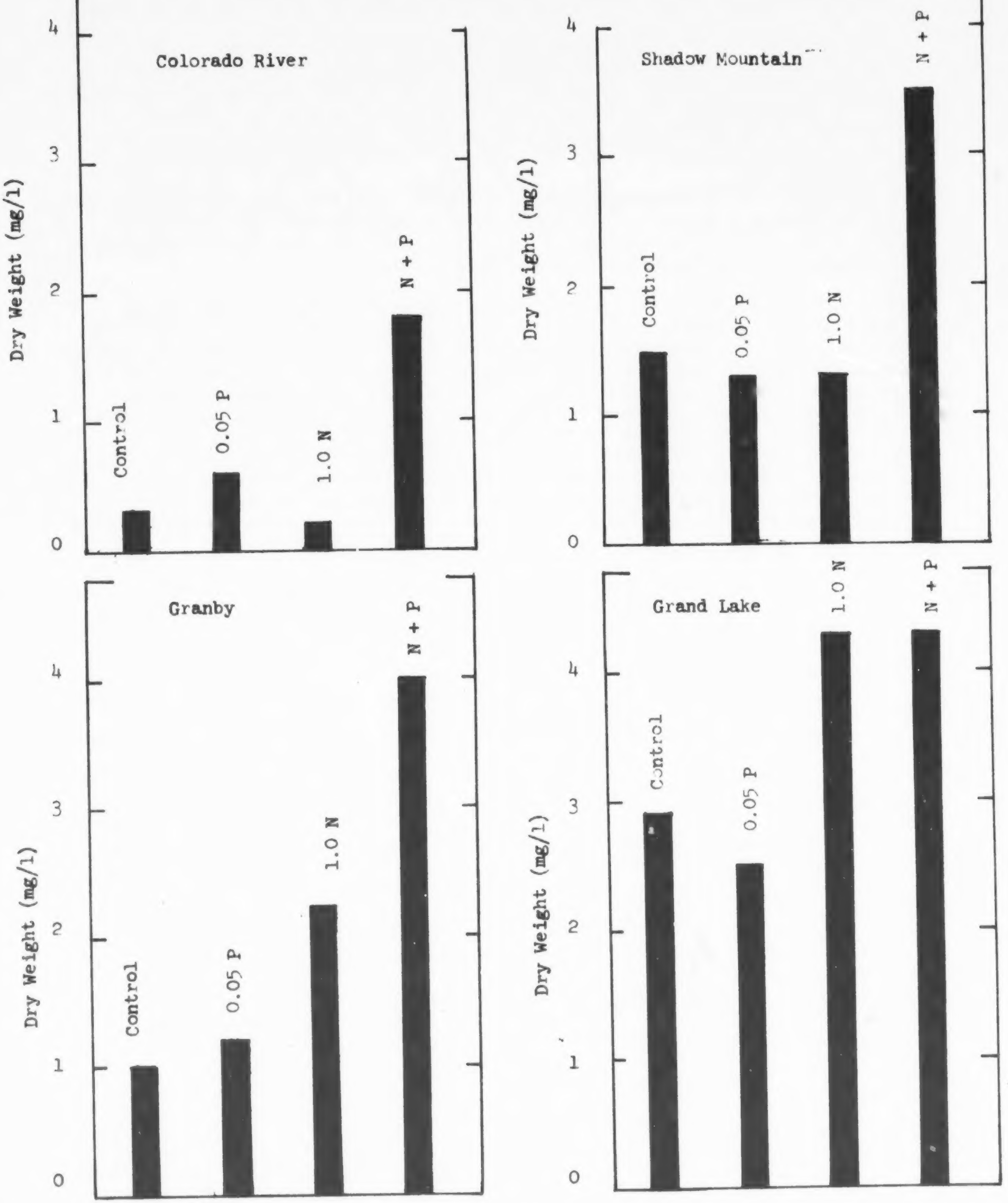
TABLE 37

CONCENTRATIONS OF ORTHOPHOSPHATE IN THE THREE LAKES AND THE COLORADO RIVER

Locations	5/30	6/7-19	6/28	7/19	8/1	8/14	9/4-19
Lake Granby							
Colorado River Arm (10)							
surface	0.002	0.004	0.006	0.013	0.001	0.002	0.003
mid	0.011	-	0.008	0.009	0.002	0.001	-
bottom	0.004	0.005	0.009	0.010	0.004	0.003	0.009
Middle (14)							
surface	0.006	0.003	0.009	0.008	0.001	0.001	0.001
mid	0.002	0.003	0.006	0.009	0.001	0.001	0.001
bottom	0.002	0.007	0.010	0.010	0.004	0.004	0.005
North (20)							
surface	0.003	0.004	0.004	0.008	0.001	0.002	0.001
mid	-	0.004	0.008	0.010	-	-	-
bottom	0.003	0.005	0.007	0.010	-	0.003	0.004
Arapahoe Arm (5)							
surface	0.002	0.002	0.003	0.019	0.001	0.001	0.002
mid	0.002	-	0.002	0.009	0.001	0.001	0.004
bottom	0.006	0.004	0.013	0.010	0.001	0.023	0.006
Shadow Mountain Lake							
North (41)							
surface	0.003	0.005	0.001	0.009	-	0.003	0.002
mid	-	-	-	-	-	-	-
bottom	-	0.008	-	-	-	-	-
Middle (37)							
surface	0.052	0.005	0.001	0.010	0.004	0.002	0.021
mid	-	-	-	-	-	-	-
bottom	0.005	0.005	0.002	0.007	-	0.004	0.006
South (28)							
surface	0.008	0.003	0.002	0.006	0.001	0.002	0.001
mid	-	-	-	-	-	-	-
bottom	0.004	0.016	0.003	-	0.003	0.003	0.001
Grand Lake							
Middle (50)							
surface	0.001	0.002	0.001	0.005	0.001	0.005	0.001
mid	0.001	0.003	0.002	0.004	0.002	0.001	0.001
bottom	0.001	0.004	0.002	0.007	0.001	0.001	0.001
Colorado River Below Lake Granby	0.007	0.006	0.014	0.010	0.001	0.008	0.017

All values reported in mg/l as P.

Figure 14. The Effect on the Seven-Day Maximum Standing Crop of *Selenastrum capricornutun* of Various Nutrient Additions to Water Taken From Lake Granby, Shadow Mountain Lake and Grand Lake, Colorado, 1974.



weight/l. The maximum standing crop in any culture flask is defined as the maximum algal biomass achieved during the incubation period (seven days).

In order to facilitate ease in discussion, only the yields for the control and the highest maximum standing crop yields for single nitrogen, phosphorus, and combined spikes are shown. In general, incremental increases in the concentration of the limiting nutrient (phosphorus or nitrogen) resulted in increased growth, while increases in the concentration of the non-limiting nutrient produced no additional growth from the control level.

Results of the Colorado River algal assay indicate phosphorus limitation at the time of sampling. Single additions of nitrogen did not result in increased growth from the control level, while single additions of phosphorus produced markedly higher maximum standing crops.

Results of the Shadow Mountain algal assay indicate both phosphorus and nitrogen limitations at the time of sampling. Neither single additions of phosphorus nor nitrogen resulted in maximum standing crops markedly greater than the control level. A large increase in growth from the control level occurred, however, with addition of the combined nitrogen and phosphorus spike. The reported value of orthophosphorus (0.052 mg/l P on May 30, 1974) is likely in error in view of the algal assay results. Although both nitrogen and phosphorus were limiting at the time of sampling, the limiting nutrient in Shadow Mountain Reservoir may change during different times of the year due to the reversible flow-thru characteristic of the reservoir. Additional algal assays would be necessary to document shifts in the limiting nutrient due to seasonal and/or man-induced hydrological changes.

Lake Granby was nitrogen limited at the time of sampling. Single additions of nitrogen resulted in a marked increase in the maximum standing crop from the level of the control. Single additions of phosphorus, however, resulted in no additional growth. As expected, the highest maximum yields were observed in the combined spikes. The algal assay with water from Grand Lake indicated nitrogen limitation at the time of sampling. Single additions of nitrogen resulted in increased maximum standing crop, while single additions of phosphorus did not. The combined phosphorus and nitrogen spikes, however, did not result in additional growth from the level observed in the single nitrogen spike, a condition possibly indicative of secondary micronutrient limitation.

Although nitrogen was identified as the limiting nutrient at the time of sampling in Grand Lake some incongruities in the data exist. It should be noted that the surface nutrient concentrations reported for 5/30/74 (date of collection of algal assay water) are dissimilar from samples collected during the following months. The differences in nutrient concentration noted on May 30, 1974 may be due to sampling during or slightly after spring overturn. On May 30, 1974 Grand Lake was nearly isothermal, only a slight change in temperature being noted with depth. Recorded surface temperature was 6.5°C while at 76m (250 ft) the temperature was 5°C. On 5/30/74, nitrite-nitrate concentrations were similar throughout the water column. However, sampling during subsequent months revealed a strong stratification of nitrite-nitrate concentrations with surface concentrations significantly lower than values reported for 5/30/76. Consequently, the algal assay results may not be indicative of the algal growth potential during different times of the year.

As previously stated, the algal assay indicated nitrogen limitation in Grand Lake at the time of sampling. On the basis of the water chemistry at the time of sampling, however, the limiting nutrient was phosphorus. Theoretically, water having a TSIN : O-PO$_4$ ratio (total soluble inorganic nitrogen (TSIN : NO$_2$ + NO$_3$+NH$_3$) : orthophosphate) of greater than 11.3:1 would likely be phosphorus limited, while a ratio less than 11.3:1 would be indicative of nitrogen limitation (Shiroyama, et al, 1975; Greene, et al; 1975). The TSIN:P ratio for water collected from Grand lake on 5/30/74 was indicative of strong phosphorus limitation.

The divergence between the observed and the theoretical limiting nutrient may be due to chemical analysis. On the basis of the dry weight yields, Shiroyama, et al, 1975 reported that dry weight yields could be predicted if no toxic substances and all essential micronutrients were present. In the control and the single phosphorus spikes, the calculated phosphorus concentration available was 0.008-0.009 mg/l P rather than the reported 0.001 mg/l P (Shiroyama, et al, 1975; Greene, et al, 1975). With a per unit TSIN and orthophosphorus concentration of 0.009 mg/l the N:P ratio would be changed to 8.3:1.

Additional algal assays are needed to document the limiting nutrient in Grand Lake during different seasons of the year. Variation in surface nutrient concentrations in Grand Lake may also occur with changes in hydrologic regulation of Grand Lake and Shadow Mountain Reservoir.

Miller, Maloney and Greene (1973) determined algal productivity in 49 lakes on the basis of dry weight yields of algal assays using *Selenastrum capricornutum*. Four productivity groups were defined: (1) low productivity (0.00 - 0.10 mg dry weight l^{-1}); (2) moderate productivity (0.11 - 0.80 mg dry weight l^{-1}); (3) moderately high productivity (0.81 - 6.00 mg dry weight l^{-1}); and (4) high productivity (6.10 - 20.00 mg dry weight l^{-1}). On the basis of the yields in the control cultures, potential primary productivity in the Three Lakes and the Colorado River downstream from Granby Reservoir ranged from moderate to moderately high productivity. As previously stated, however, the results of the algal assays reflect only the conditions existing at the time of sampling at the specific sampling site. Due to the complex hydrological nature of the Three Lakes system and the variation observed in nutrient concentrations during this survey, additional algal assays are recommended.

APPENDIX A

SURVEY DATA

Three Lakes Study

Sampling Station Locations

Station No.	Description
1	Arapaho Creek at Bridge, Lake Granby
2	Arapaho Bay, Lake Granby
3	Roaring Fork Creek Mouth at Lake Granby
4	Lake Granby, Transect at Twin Pines Point
5	Lake Granby, Transect at Twin Pines Point
6	Lake Granby, Transect at Twin Pines Point
7	Lake Granby, Transect at Rocky Point
8	Lake Granby, Transect at Rocky Point
9	Lake Granby, Transect at Rocky Point
10	Lake Granby at Grand Bay
11	Twin Creek Mouth at Lake Granby
12	Columbine Creek Mouth at Lake Granby
13	Lake Granby, Transect at Sunset Point
14	Lake Granby, Transect at Sunset Point
15	Lake Granby, Transect at Sunset Point
16	Lake Granby at Rainbow Bay
17	Lake Granby at Kokanee Bay
18	Lake Granby Midway Between Kokanee and Fish Bays
19	Lake Granby, Transect Fish Bay to Rainbow Island

Sampling Station Locations

(Continued)

Station No.	Description
20	Lake Granby, Transect Fish Bay to Rainbow Island
21	Lake Granby, Transect Fish Bay to Rainbow Island
22	Lake Granby at NPS Campground Launch Area
23	Lake Granby at Cutthroat Trout Bay
24	Stillwater Creek near Shadow Mountain Lake
24-A	Stillwater Creek at Arapaho National Forest
25	Soda Creek near Shadow Mountain Lake
25-A	Soda Creek at Arapaho National Forest
26	Shadow Mountain - Granby Pump Canal
27	Shadow Mountain Lake, Transect at South End of Lake
28	Shadow Mountain Lake, Transect at South End of Lake
29	Shadow Mountain Lake, Transect at South End of Lake
30	Recreation Area STP Evaporation Pond
31	Colorado River at Shadow Mountain Lake
31-A	Colorado River in Rocky Mountain National Park
32	Shadow Mountain Lake, Transect at North Side of Islands
33	Shadow Mountain Lake, Transect at North Side of Islands
34	Shadow Mountain Lake, Transect at North Side of Islands
35	Shadow Mountain Lake at Boat Docks West Side of Lake
36	Shadow Mountain Lake, Transect at Center of Lake
37	Shadow Mountain Lake, Transect at Center of Lake

Sampling Station Locations

(Continued)

Station No.	Description
38	Shadow Mountain Lake, Transect at Center of Lake
39	Shadow Mountain Lake at Boat Docks West Side of Lake
40	Shadow Mountain Lake, Transect at North End of Lake
41	Shadow Mountain Lake, Transect at North End of Lake
42	Shadow Mountain Lake, Transect at North End of Lake
43	Grand Lake STP Effluent
44	Little Columbine Creek near Grand Lake/Shadow Mountain Lake
45	Grand Lake at Outlet Between Lakes
46	Grand Lake, Transect at West End of Lake
47	Grand Lake, Transect at West End of Lake
48	Grand Lake, Transect at West End of Lake
49	Grand Lake, Transect at Center of Lake
50	Grand Lake, Transect at Center of Lake
51	Grand Lake, Transect at Center of Lake
52	Grand Lake North Inlet
53	Grand Lake, Transect at East End of Lake
54	Grand Lake, Transect at East End of Lake
55	Grand Lake, Transect at East End of Lake
56	Grand Lake Inlet to Adams Tunnel
57	Grand Lake East Inlet
58	Colorado River Downstream Lake Granby

Primary Productivity Rates for Lake Granby

9/13/74

Station	Depth (Meters)	Productivity Rate Mg C/m^3/day
2	Surf.	59.4
	2.4	50.5
	4.75	15.5
5	Surf.	29.9
	2.5	48.6
	5.0	27.7
8	Surf.	30.2
	2.75	56.7
	5.5	28.2
10	Surf.	52.5
	2.6	66.7
	5.2	25.1

9/11/74

Station	Depth (Meters)	Productivity Rate Mg C/m^3/day
14	Surf.	61.4
	2.5	71.3
	5.0	17.3
16	Surf.	56.2
	2.4	59.8
	4.75	27.4
20	Surf.	48.2
	2.3	53.5
	4.6	23.7
23	Surf.	50.0
	2.0	4.9
	4.0	17.8

Primary Productivity Rates for Grand Lake and Shadow Mountain Lake

9/10/74

Station	Depth (Meters)	Productivity Rate Mg C/m^3/day
47	Surf.	50.8
	2.3	48.7
	4.6	10.4
50	Surf.	87.3
	2.75	29.4
	5.5	6.3
54	Surf.	135.1
	2.75	51.6
	5.5	10.0

9/9/74

Station	Depth (Meters)	Productivity Rate Mg C/m^3/day
28	Surf.	71.0
	2.4	44.6
	4.0	6.5
33	Surf.	98.0
	2.4	53.8
	4.0	18.9
37	Surf.	80.5
	2.4	48.6
	4.75	5.9

THREE LAKES STUDY

Station: 1 Arapaho Creek at Lake Granby

Date	Yr/Mo/Day	74/06/07	74/06/09	74/06/10
Time	Mtly.	1300	0730	0740
Temp.	Cent.	4.5	1.0	1.0
Flow	m^3/s	14.3	-	-
pH	SU	7.2	7.9	7.3
Conductivity	μmhos	<50	<50	<50
DO	mg/l	9.6	10.3	10.3
BOD_5	mg/l	1	<1	<1
TKN	mg/l	0.28	0.19	0.24
NO_2+NO_3-N	mg/l	0.040	0.032	0.030
NH_3-N	mg/l	0.007	0.003	0.003
Total-P	mg/l	0.005	0.005	0.002
Ortho-P	mg/l	0.002	0.003	0.001
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	0.37	0.52	0.46
Alkalinity	mg/l	12.4	12.4	12.4
Suspended Solids	mg/l	5	3	4
T. Coli.	#/100ml	12	<1	<1
F. Coli.	#/100ml	2	<1	<1

THREE LAKES STUDY

Station: 3 Roaring Fork at Lake Granby

Date	Yr/Mo/Day	74/06/07	74/06/09	74/06/10
Time	Mtly.	1315	0745	0800
Temp.	Cent.	2.0	0	0
Flow	m^3/s	1.7	-	-
pH	SU	7.2	7.0	7.5
Conductivity	μmhos	<50	<50	<50
DO	mg/l	9.7	10.4	10.8
BOD_5	mg/l	<1	<1	<1
TKN	mg/l	0.36	0.12	0.22
NO_2+NO_3-N	mg/l	0.039	0.044	0.038
NH_3-N	mg/l	0.012	0.002	0.021
Total-P	mg/l	0.008	0.004	0.013
Ortho-P	mg/l	0.003	0.004	0.001
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	0.31	0.26	0.38
Alkalinity	mg/l	10.3	10.3	12.4
Suspended Solids	mg/l	5	3	2
T. Coli.	#/100ml	2	<1	<1
F. Coli.	#/100ml	2	<1	<1

THREE LAKES STUDY

Station: 11 Twin Creek at Lake Granby

Date	Yr/Mo/Day	74/06/07	74/06/09	74/06/10
Time	Mtly.	1015	1030	1000
Temp.	Cent.	3.0	2.0	3.0
Flow	m^3/s	0.6	-	-
pH	SU	7.4	7.3	7.1
Conductivity	μmhos	<50	<50	<50
DO	mg/l	10.0	10.2	10.3
BOD_5	mg/l	<1	<1	<1
TKN	mg/l	0.16	0.18	0.19
NO_2+NO_3-N	mg/l	0.002	0.006	0.002
NH_3-N	mg/l	0.003	<0.002	0.003
Total-P	mg/l	0.009	0.015	0.006
Ortho-P	mg/l	0.003	0.006	0.004
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	0.64	0.67	0.72
Alkalinity	mg/l	8.2	12.4	10.3
Suspended Solids	mg/l	7	8	6
T. Coli.	#/100ml	10	<1	1
F. Coli.	#/100ml	<2	<1	1

THREE LAKES STUDY

Station: 12 Columbine Creek at Lake Granby

Date	Yr/Mo/Day	74/06/07	74/06/09	74/06/10
Time	Mtly.	1100	1100	1025
Temp.	Cent.	2.5	1.0	3.0
Flow	m^3/s	0.8	-	-
pH	SU	7.4	7.3	7.4
Conductivity	μmhos	<50	<50	<50
DO	mg/l	9.9	10.2	10.2
BOD_5	mg/l	<1	<1	<1
TKN	mg/l	0.17	0.18	0.23
NO_2+NO_3-N	mg/l	0.006	0.009	0.004
NH_3-N	mg/l	0.004	0.003	0.002
Total-P	mg/l	0.007	0.025	0.051
Ortho-P	mg/l	0.002	0.004	0.001
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	0.42	0.79	0.49
Alkalinity	mg/l	-	12.4	8.2
Suspended Solids	mg/l	4	6	3
T. Coli.	#/100ml	5	1	3
F. Coli.	#/100ml	<2	1	3

THREE LAKES STUDY

Station: 24 Stillwater Creek near Shadow Mt. Lake

Date	Yr/Mo/Day	74/06/14	74/06/16	74/06/17
Time	Mtly.	1045	1025	1205
Temp.	Cent.	11.0	11.5	15.0
Flow	m^3/s	1.0	-	-
pH	SU	8.0	7.7	7.5
Conductivity	μmhos	98	110	100
DO	mg/l	8.2	8.4	7.6
BOD_5	mg/l	1.3	1.1	1.3
TKN	mg/l	0.61	0.40	0.63
NO_2+NO_3-N	mg/l	0.027	0.029	0.023
NH_3-N	mg/l	0.011	0.007	0.010
Total-P	mg/l	0.155	0.107	0.201
Ortho-P	mg/l	0.067	0.066	0.071
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	4.8	5.9	6.9
Alkalinity	mg/l	41.2	43.3	45.3
Suspended Solids	mg/l	31	35	43
T. Coli.	#/100ml	300	600	620
F. Coli.	#/100ml	240	550	430

THREE LAKES STUDY

Station: 24-A Stillwater Creek at Arapaho National Forest

Date	Yr/Mo/Day	74/06/14	74/06/16	74/06/17
Time	Mtly.	1020	1005	1235
Temp.	Cent.	7.5	8.0	10.5
Flow	m^3/s	1.1	-	-
pH	SU	7.6	7.1	7.2
Conductivity	µmhos	<50	<50	<50
DO	mg/l	8.8	8.8	8.3
BOD_5	mg/l	1.1	1.1	<1
TKN	mg/l	0.55	0.26	0.30
NO_2+NO_3-N	mg/l	0.003	0.003	0.001
NH_3-N	mg/l	0.025	<0.002	0.003
Total-P	mg/l	0.154	0.036	0.036
Ortho-P	mg/l	0.041	0.026	0.024
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	1.7	1.6	1.7
Alkalinity	mg/l	14.4	12.4	14.4
Suspended Solids	mg/l	8	10	7
T. Coli.	#/100ml	<1	<1	2
F. Coli.	#/100ml	<1	<1	<2

THREE LAKES STUDY

Station: 25 Soda Creek near Shadow Mt. Lake

Date	Yr/Mo/Day	74/06/11	74/06/12	74/06/13
Time	Mtly.	1130	1320	0930
Temp.	Cent.	9.5	13.5	10.5
Flow	m^3/s	0.08	-	-
pH	SU	7.4	7.4	7.4
Conductivity	μmhos	67	89	76
DO	mg/l	8.3	7.5	7.9
BOD_5	mg/l	1.2	<1	1
TKN	mg/l	0.72	0.70	0.79
NO_2+NO_3-N	mg/l	0.006	0.009	0.007
NH_3-N	mg/l	0.018	0.020	0.012
Total-P	mg/l	0.058	0.078	0.084
Ortho-P	mg/l	0.039	0.050	0.052
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	6.0	6.0	3.6
Alkalinity	mg/l	26.8	31.0	28.8
Suspended Solids	mg/l	10	11	10
T. Coli.	#/100ml	110	56	180
F. Coli.	#/100ml	100	56	75

THREE LAKES STUDY

Station: 25-A Soda Creek at Arapaho National Forest

Date	Yr/Mo/Day	74/06/11	74/06/12	74/06/13
Time	Mtly.	1100	1300	0910
Temp.	Cent.	6.0	11.0	5.0
Flow	m^3/s	0.3	-	-
pH	SU	7.2	7.1	7.3
Conductivity	μmhos	<50	<50	<50
DO	mg/l	8.8	7.8	9.1
BOD_5	mg/l	<1	<1	<1
TKN	mg/l	0.30	0.17	0.31
NO_2+NO_3-N	mg/l	0.001	0.006	0.001
NH_3-N	mg/l	0.011	0.016	<0.002
Total-P	mg/l	0.027	0.041	0.028
Ortho-P	mg/l	0.020	0.036	0.016
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	2.0	0.78	0.9
Alkalinity	mg/l	10.3	10.3	10.3
Suspended Solids	mg/l	5	4	4
T. Coli.	#/100ml	15	<1	8
F. Coli.	#/100ml	15	<1	2

THREE LAKES STUDY

Station: 26 Shadow Mountain / Granby Pump Canal

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	0930	0905	0900
Temp.	Cent.	13.0	13.5	13.0
Flow	m^3/s	-	-	-
pH	SU	7.5	7.5	7.7
Conductivity	µmhos	55	55	55
DO	mg/l	8.0	7.9	7.9
BOD_5	mg/l	<1	1.1	1.4
TKN	mg/l	0.57	0.52	0.31
NO_2+NO_3-N	mg/l	0.001	0.002	0.004
NH_3-N	mg/l	0.004	<0.002	<0.002
Total-P	mg/l	0.014	0.019	0.019
Ortho-P	mg/l	0.005	0.003	0.007
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	2.8	2.8	3.1
Alkalinity	mg/l	18.5	18.5	18.5
Suspended Solids	mg/l	8	9	10
T. Coli.	#/100ml	2	15	-
F. Coli.	#/100ml	2	3	-

THREE LAKES STUDY

Station: 30 Recreation Area STP Evaporation Pond

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	1105	1005	1045
Temp.	Cent.	18	17	18
Flow	m^3/s	*	*	*
pH	SU	7.6	7.9	7.6
Conductivity	µmhos	165	165	165
DO	mg/l	4.3	3.3	2.2
BOD_5	mg/l	4	4	4
TKN	mg/l	2.6	8.0	1.9
NO_2+NO_3-N	mg/l	0.001	0.004	0.004
NH_3-N	mg/l	0.132	0.204	0.204
Total-P	mg/l	0.255	0.352	0.459
Ortho-P	mg/l	0.237	0.42	0.42
Cl_2 Residual	mg/l	0	0	0
Turbidity	JTU	4.1	4.5	5.6
Alkalinity	mg/l	70	68	68
Suspended Solids	mg/l	12	9	9
T. Coli.	#/100ml	5	8	10
F. Coli.	#/100ml	5	4	5

* No discharge.

THREE LAKES STUDY

Station: 31 Colorado River at Shadow Mountain Lake

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	1130	1015	1100
Temp.	Cent.	10	9	8.5
Flow	m^3/s	-	-	-
pH	SU	7.9	7.5	8.1
Conductivity	µmhos	<50	<50	<50
DO	mg/l	8.6	8.8	9.0
BOD_5	mg/l	1.1	<1	<1
TKN	mg/l	0.57	0.49	0.40
NO_2+NO_3-N	mg/l	0.006	0.008	0.008
NH_3-N	mg/l	0.009	0.003	0.003
Total-P	mg/l	0.016	0.038	0.038
Ortho-P	mg/l	0.009	0.007	0.007
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	4.2	4.7	5.0
Alkalinity	mg/l	16.5	16.5	12.4
Suspended Solids	mg/l	18	19	19
T. Coli.	#/100ml	36	130	80
F. Coli.	#/100ml	20	32	44

THREE LAKES STUDY

Station: 31-A Colorado River in Rocky Mountain National Park

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	1240	1100	1200
Temp.	Cent.	9.0	7.0	8.0
Flow	m^3/s	6.3	-	-
pH	SU	7.5	7.0	7.1
Conductivity	µmhos	<50	<50	<50
DO	mg/l	8.7	8.9	8.8
BOD$_5$	mg/l	<1	1.2	1.2
TKN	mg/l	0.37	0.89	0.22
NO$_2$+NO$_3$-N	mg/l	0.013	0.013	0.013
NH$_3$-N	mg/l	0.018	<0.002	<0.002
Total-P	mg/l	0.008	0.022	0.019
Ortho-P	mg/l	0.007	0.005	0.005
Cl$_2$ Residual	mg/l	-	-	-
Turbidity	JTU	2.2	2.8	2.4
Alkalinity	mg/l	16.5	18.5	14.4
Suspended Solids	mg/l	10	11	11
T. Coli.	#/100ml	55	36	35
F. Coli.	#/100ml	10	24	30

THREE LAKES STUDY

Station: 43 Grand Lake STP Effluent

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	1215	1040	1120
Temp.	Cent.	9.0	8.0	9.0
Flow	m^3/s	0.010a 0.003b	-	-
pH	SU	7.1	6.4	6.7
Conductivity	μmhos	75	170	170
DO	mg/l	6.5	6.5	6.2
BOD_5	mg/l	31	34	38
TKN	mg/l	7.8	8.2	13.0
NO_2+NO_3-N	mg/l	0.116	0.014	0.119
NH_3-N	mg/l	2.6	2.7	2.9
Total-P	mg/l	1.71	1.92	2.03
Ortho-P	mg/l	0.73	0.82	1.06
Cl_2 Residual	mg/l	0	0.5	0.15
Turbidity	JTU	9.5	12	13
Alkalinity	mg/l	35	30.9	37.1
Suspended Solids	mg/l	31	21	29
T. Coli.	#/100ml	700,000	10	270
F. Coli.	#/100ml	500,000	6	60

a - Normal flow reported by plant personnel with lift station operating.

b - Measured flow during sampling period without lift station.

THREE LAKES STUDY

Station: 44 Little Columbine Creek near Grand Lake

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	1210	1030	1115
Temp.	Cent.	15	13	14
Flow	m^3/s	0.1	-	-
pH	SU	8.0	6.4	7.7
Conductivity	μmhos	89	72	90
DO	mg/l	-	7.7	7.5
BOD_5	mg/l	<1	<1	1.0
TKN	mg/l	0.48	0.45	0.42
NO_2+NO_3-N	mg/l	0.017	0.018	0.021
NH_3-N	mg/l	0.022	0.021	0.029
Total-P	mg/l	0.059	0.072	0.083
Ortho-P	mg/l	0.038	0.038	0.047
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	3.0	3.1	3.3
Alkalinity	mg/l	37.1	37.1	37.1
Suspended Solids	mg/l	15	11	10
T. Coli.	#/100ml	1200	3500	7300
F. Coli.	#/100ml	950	2700	3400

THREE LAKES STUDY

Station: 52 Grand Lake North Inlet

Date	Yr/Mo/Day	74/06/17	74/06/18	74/06/19
Time	Mtly.	0830	0805	0825
Temp.	Cent.	4.0	3.0	4.5
Flow	m^3/s	7.3	-	-
pH	SU	7.1	7.2	6.7
Conductivity	μmhos	<50	<50	<50
DO	mg/l	10.4	10.1	10.0
BOD_5	mg/l	<1	<1	1.2
TKN	mg/l	0.24	0.21	0.39
NO_2+NO_3-N	mg/l	0.028	0.026	0.024
NH_3-N	mg/l	0.007	-	<0.002
Total-P	mg/l	0.016	0.036	0.010
Ortho-P	mg/l	0.004	0.005	0.001
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	0.82	0.85	1.6
Alkalinity	mg/l	6.2	4.1	4.1
Suspended Solids	mg/l	6	3	5
T. Coli.	#/100ml	28	25	20
F. Coli.	#/100ml	20	17	14

THREE LAKES STUDY

Station: 57 Grand Lake East Inlet

Date	Yr/Mo/Day	74/06/17	74/06/18	74/06/19
Time	Mtly.	1020	0935	0945
Temp.	Cent.	5.0	4.5	6.0
Flow	m^3/s	11.5	-	-
pH	SU	6.5	6.9	6.8
Conductivity	μmhos	<50	<50	<50
DO	mg/l	10.3	10.2	10.1
BOD_5	mg/l	<1	<1	<1
TKN	mg/l	0.28	0.25	0.61
NO_2+NO_3-N	mg/l	0.021	0.020	0.024
NH_3-N	mg/l	0.005	0.005	0.002
Total-P	mg/l	0.012	0.053	0.010
Ortho-P	mg/l	0.002	0.001	0.005
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	0.68	0.61	0.56
Alkalinity	mg/l	4.1	4.1	4.1
Suspended Solids	mg/l	6	3	2
T. Coli.	#/100ml	26	8	54
F. Coli.	#/100ml	23	4	25

THREE LAKES STUDY

Station: 58 Colorado River Downstream Lake Granby

Date	Yr/Mo/Day	74/06/07	74/06/09	74/06/10
Time	Mtly.	1400	1205	1325
Temp.	Cent.	6.5	6.5	10.0
Flow*	m^3/s	2.26	1.90	1.90
pH	SU	7.5	7.3	7.7
Conductivity	µmhos	80	69	65
DO	mg/l	9.4	9.3	8.9
BOD_5	mg/l	1.6	<1	<1
TKN	mg/l	0.39	0.30	0.29
NO_2+NO_3-N	mg/l	0.076	0.068	0.065
NH_3-N	mg/l	0.019	0.012	0.005
Total-P	mg/l	0.025	0.017	0.010
Ortho-P	mg/l	0.007	0.009	0.006
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	0.94	0.93	0.63
Alkalinity	mg/l	26.8	24.7	12.4
Suspended Solids	mg/l	13	4	5
T. Coli.	#/100ml	70	180	6
F. Coli.	#/100ml	5	160	4

* Flow values obtained from USGS.

THREE LAKES STUDY

Station: 2 Lake Granby - Arapahoe Bay

Date	Yr/Mo/Day	74/06/07	74/06/09	74/06/10	74/06/07	74/06/09	74/06/10
Time	Mtly.	0710	0710	0725	0710	0710	0725
Depth		S	S	S	B	B	B
Temp.	Cent.	3.5	1.5	2.0	3.5	2.5	2.5
pH	SU	7.5	8.1	7.9	7.4	7.8	7.7
Conductivity	µ mhos	<50	<50	<50	<50	<50	<50
DO	mg/l	9.7	10	10.1	9.0	9.6	10.1
TKN	mg/l	0.68	0.38	0.26	0.46	0.30	0.25
NO_2+NO_3-N	mg/l	0.034	0.033	0.029	0.032	0.027	0.024
NH_3-N	mg/l	<0.002	0.002	<0.002	<0.002	<0.002	<0.002
Total-P	mg/l	0.011	0.005	0.001	0.017	0.009	0.001
Ortho-P	mg/l	0.004	0.001	0.001	0.006	<0.001	0.001
Alkalinity	mg/l	10.3	12.4	14.4	14.4	14.4	12.4
Turbidity	JTU	0.47	0.46	0.66	0.56	0.76	0.51
T. Coli.	#/100ml	10	4	1	-	-	-
F. Coli.	#/100ml	10	2	1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 4 Lake Granby - Transect at Twin Pines Point

Date	Yr/Mo/Day	74/06/07	74/06/09	74/06/10	74/06/07	74/06/09	74/06/10
Time	Mtly.	0830	0830	0830	0830	0830	0830
Depth		S	S	S	B	B	B
Temp.	Cent.	9.5	7.5	8.0	6.0	6.0	7.6
pH	SU	8.0	8.0	7.8	7.8	7.6	7.9
Conductivity	µ mhos	60	59	60	55	83	60
DO	mg/l	9.9	9.0	9.1	8.4	8.4	8.9
TKN	mg/l	0.53	0.42	0.29	0.32	0.28	0.31
NO_2+NO_3-N	mg/l	0.001	0.005	0.001	0.035	0.036	<0.001
NH_3-N	mg/l	<0.002	<0.002	<0.002	0.003	0.004	0.002
Total-P	mg/l	0.021	0.011	0.008	0.018	0.012	0.014
Ortho-P	mg/l	0.003	0.003	0.002	0.003	0.002	0.004
Alkalinity	mg/l	24.7	20.6	20.6	22.7	22.7	22.7
Turbidity	JTU	0.85	0.62	0.66	3.0	0.95	0.66
T. Coli.	#/100ml	4	2	<1	-	-	-
F. Coli.	#/100ml	<2	2	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 5 Lake Granby - Transect at Twin Pines Point

Date	Yr/Mo/Day	74/06/07	74/06/09	74/06/10	74/06/07	74/06/09	74/06/10	74/06/07	74/06/09	74/06/10
Time	Mtly.	0815	0815	0820	0815	0815	0820	0815	0815	0820
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	9.0	7.5	8.0	8.5	8.0	7.5	5.5	5.0	5.0
pH	SU	8.1	7.9	7.7	8.1	7.9	7.6	7.8	7.0	7.4
Conductivity	µ mhos	61	59	59	56	58	58	62	59	68
DO	mg/l	9.4	8.9	8.9	9.3	8.9	9.2	8.0	8.0	7.8
TKN	mg/l	0.35	0.26	0.29	0.39	0.26	0.35	0.87	0.22	0.23
NO_2+NO_3-N	mg/l	0.001	0.006	<0.001	0.006	0.005	<0.001	0.054	0.050	0.057
NH_3-N	mg/l	<0.002	<0.002	<0.002	<0.002	0.004	0.004	0.007	0.008	0.013
Total-P	mg/l	0.016	0.013	0.012	0.010	0.014	0.012	0.129	0.024	0.010
Ortho-P	mg/l	0.003	0.002	0.002	0.003	0.002	0.003	0.007	0.003	0.004
Alkalinity	mg/l	26.8	22.7	18.5	-	22.7	20.6	22.7	24.7	24.7
Turbidity	JTU	0.79	0.63	0.81	0.83	0.68	0.65	9.0	3.0	0.82
T. Coli.	#/100ml	20	<1	<1	-	-	-	-	-	-
F. Coli.	#/100ml	2	<1	<1	-	-	-	-	-	-

S = Surface M = Thermocline B= Bottom

THREE LAKES STUDY

Station: 6 Lake Granby - Transect at Twin Pines Point

Date	Yr/Mo/Day	74/06/07	74/06/09	74/06/10	74/06/07	74/06/09	74/06/10
Time	Mtly.	0730	0800	0810	0730	0800	0810
Depth		S	S	S	B	B	B
Temp.	Cent.	9.0	7.5	7.5	9.0	7.0	6.0
pH	SU	7.8	7.7	7.7	8.1	7.6	7.6
Conductivity	μ mhos	57	57	59	59	<50	56
DO	mg/l	9.4	9.0	9.2	9.1	8.7	8.5
TKN	mg/l	0.33	0.28	0.26	0.40	0.28	0.30
NO_2+NO_3-N	mg/l	0.001	0.005	0.002	0.001	0.011	0.015
NH_3-N	mg/l	<0.002	0.003	0.003	<0.002	0.002	0.003
Total-P	mg/l	0.016	0.019	0.010	0.017	0.016	0.013
Ortho-P	mg/l	0.004	0.003	0.003	0.004	0.002	0.004
Alkalinity	mg/l	20.6	22.7	20.6	22.7	20.6	20.6
Turbidity	JTU	0.72	0.63	0.72	0.75	0.86	0.71
T. Coli.	#/100ml	28	4	2	-	-	-
F. Coli.	#/100ml	5	4	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKE STUDY

Station:	7	Lake Granby - Transect at Rocky Point								
Date	Yr/Mo/Day	74/06/07	74/06/09	74/06/10	74/06/07	74/06/09	74/06/10	74/06/07	74/06/09	74/06/10
Time	Mtly.	0850	0900	0640	0850	0900	0640	0850	0900	0640
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	8.5	7.0	7.5	7.5	6.0	5.5	6.0	4.5	4.5
pH	SU	8.1	8.1	7.0	7.8	7.9	7.2	7.5	7.6	7.2
Conductivity	μ mhos	58	66	69	64	68	68	74	61	68
DO	mg/l	9.2	9.1	9.1	8.8	8.5	8.3	8.7	8.0	8.1
TKN	mg/l	0.32	0.26	0.29	0.28	0.28	0.20	0.50	0.22	0.32
NO_2+NO_3-N	mg/l	0.001	0.005	0.001	0.018	0.029	0.041	0.039	0.067	0.058
NH_3-N	mg/l	0.003	<0.002	0.001	0.003	0.004	0.010	0.007	0.013	0.014
Total-P	mg/l	0.013	0.017	0.017	0.011	0.011	0.010	0.076	0.009	0.057
Ortho-P	mg/l	0.003	0.003	0.004	0.004	0.002	0.003	0.006	0.003	0.009
Alkalinity	mg/l	24.7	24.7	22.7	24.7	26.8	22.7	26.8	26.8	24.7
Turbidity	JTU	0.70	0.60	0.83	0.78	0.80	0.71	32	0.86	23
T. Coli.	#/100ml	<2	<1	<1	-	-	-	-	-	-
F. Coli.	#/100ml	<2	<1	<1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 8 Lake Granby - Transect at Rocky Point

Date	Yr/Mo/Day	74/06/07	74/06/09	74/06/10	74/06/07	74/06/09	74/06/10	74/06/07	74/06/09	74/06/10
Time	Mtly.	0910	0910	0855	0910	0910	0855	0910	0910	0855
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	9.0	7.5	7.5	7.0	8.0	7.5	5.0	4.5	5.0
pH	SU	8.0	8.1	8.1	7.7	8.1	7.8	7.8	7.6	7.6
Conductivity	μ mhos	61	62	60	62	60	60	65	55	66
DO	mg/l	9.4	9.1	9.2	8.9	9.1	8.8	8.2	8.0	8.3
TKN	mg/l	0.31	0.28	0.22	0.29	0.26	0.23	0.31	0.28	0.15
NO_2+NO_3-N	mg/l	0.001	0.004	0.002	0.024	0.004	0.017	0.067	0.068	0.067
NH_3-N	mg/l	<0.002	0.004	0.012	0.003	0.002	0.005	0.014	0.015	0.015
Total-P	mg/l	0.011	0.013	0.013	0.012	0.012	0.011	0.012	0.016	0.011
Ortho-P	mg/l	0.005	0.003	0.004	0.003	0.003	0.004	0.004	0.005	0.004
Alkalinity	mg/l	24.7	24.7	20.6	24.7	24.7	22.7	22.7	24.7	22.7
Turbidity	JTU	0.69	0.68	0.69	0.68	0.71	0.65	0.69	0.94	2.5
T. Coli.	#/100ml	<2	1	<1	-	-	-	-	-	-
F. Coli.	#/100ml	<2	<1	<1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 9 Lake Granby - Transect at Rocky Point

Date	Yr/Mo/Day	74/06/07	74/06/09	74/06/10	74/06/07	74/06/09	74/06/10	74/06/07	74/06/09	74/06/10
Time	**Mtly.**	0930	0930	0915	0930	0930	0915	0930	0930	0915
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	8.5	7.0	7.0	9.0	6.5	7.0	4.5	4.0	6.0
pH	SU	7.8	7.8	8.3	7.6	7.8	7.8	7.5	7.6	7.7
Conductivity	µ mhos	58	60	60	55	54	60	63	64	60
DO	mg/l	9.3	9.0	9.2	8.9	8.5	8.7	8.0	7.8	8.2
TKN	mg/l	0.35	0.26	0.15	0.25	0.40	0.18	0.27	0.26	0.14
NO_2+NO_3-N	mg/l	0.001	0.004	0.001	0.004	0.019	0.016	0.070	0.071	0.038
NH_3-N	mg/l	<0.002	0.002	0.004	0.004	0.002	0.001	0.017	0.014	0.009
Total-P	mg/l	0.013	0.011	0.010	0.011	0.010	0.014	0.009	0.006	0.009
Ortho-P	mg/l	0.003	0.004	0.002	0.002	0.003	0.003	0.003	0.004	0.003
Alkalinity	mg/l	24.7	22.7	22.7	20.6	18.5	20.6	26.8	24.7	22.7
Turbidity	**JTU**	0.86	0.68	0.66	0.67	0.63	0.71	0.72	0.66	0.71
T. Coli.	#/100ml	<2	<1	<1	-	-	-	-	-	-
F. Coli.	#/100ml	<2	<1	<1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 10 Lake Granby - Transect at Grand Bay

Date	Yr/Mo/Day	74/06/07	74/06/09	74/06/10	74/06/07	74/06/09	74/06/10
Time	Mtly.	0950	1000	0930	0950	1000	0930
Depth		S	S	S	B	B	B
Temp.	Cent..	9.5	8.0	8.0	5.0	5.0	5.0
pH	SU	7.8	7.5	7.7	7.5	7.3	7.4
Conductivity	µ mhos	<50	50	58	61	60	68
DO	mg/1	8.6	8.4	8.8	7.8	7.6	7.8
TKN	mg/1	0.30	0.31	0.15	0.56	0.39	0.16
NO_2+NO_3-N	mg/1	0.001	0.004	0.003	0.062	0.064	0.061
NH_3-N	mg/1	0.003	<0.002	0.003	0.033	0.024	0.023
Total-P	mg/1	0.012	0.008	0.010	0.053	0.060	0.015
Ortho-P	mg/1	0.003	0.002	0.004	0.009	0.011	0.005
Alkalinity	mg/1	18.5	20.6	18.5	24.7	26.8	22.7
Turbidity	JTU	0.84	0.74	0.71	6	14	4
T. Coli.	#/100ml	2	1	<1	-	-	-
F. Coli.	#/100ml	<2	1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 13 Lake Granby - Transect at Sunset Point

Date	Yr/Mo/Day	74/06/11	74/06/12	74/06/13	74/06/11	74/06/12	74/06/13
Time	Mtly.	0745	0730	0720	0745	0730	0720
Depth		S	S	S	B	B	B
Temp.	Cent.	8.0	9.2	10.0	8.0	9.0	9.5
pH	SU	8.0	8.1	7.8	7.9	8.3	8.1
Conductivity	µ mhos	<50	<50	<50	<50	<50	50
DO	mg/l	9.1	9.0	10.0	9.1	9.3	8.1
TKN	mg/l	0.34	0.14	0.34	0.32	0.30	0.33
NO_2+NO_3-N	mg/l	<0.001	0.001	0.001	<0.001	<0.001	0.003
NH_3-N	mg/l	<0.002	0.006	<0.002	0.002	0.012	<0.002
Total-P	mg/l	0.012	0.019	0.020	0.048	0.022	0.035
Ortho-P	mg/l	0.002	0.008	0.002	0.004	0.008	0.003
Alkalinity	mg/l	24.7	22.7	20.6	22.7	22.7	22.7
Turbidity	JTU	0.83	0.91	1.5	4.0	0.67	3
T. Coli.	#/100ml	<1	<1	2	-	-	-
F. Coli.	#/100ml	<1	<1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 14 Lake Granby - Transect of Sunset Point

Date	Yr/Mo/Day	74/06/11	74/06/12	74/06/13	74/06/11	74/06/12	74/06/13	74/06/11	74/06/12	74/06/13
Time	Mtly.	0800	0740	0730	0800	0740	0730	0800	0740	0730
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	8.5	9.0	9.0	7.0	8.0	7.5	5.0	5.0	5.0
pH	SU	8.2	8.3	8.2	7.7	7.8	8.0	7.9	7.3	7.9
Conductivity	μ mhos	<50	60	62	50	60	63	<50	65	<50
DO	mg/1	9.1	9.1	9.2	8.8	8.8	8.9	7.8	7.3	7.8
TKN	mg/1	0.23	0.22	0.31	0.20	0.24	0.27	0.20	0.53	0.28
NO_2+NO_3-N	mg/1	<0.001	<0.001	<0.001	0.013	0.003	0.002	0.062	0.060	0.060
NH_3-N	mg/1	<0.002	0.016	0.002	0.005	0.011	<0.002	0.021	0.036	0.015
Total-P	mg/1	0.013	0.020	0.013	0.028	0.016	0.014	0.020	0.126	0.026
Ortho-P	mg/1	0.001	0.008	0.003	0.002	0.005	0.003	0.004	0.018	0.007
Alkalinity	mg/1	22.7	22.7	22.7	24.7	22.7	22.7	24.7	24.7	24.7
Turbidity	JTU	0.80	0.63	0.71	0.79	0.62	1.1	3.0	9.0	2.5
T. Coli.	#/100ml	<1	<1	<1	-	-	-	-	-	-
F. Coli.	#/100ml	<1	<1	<1	-	-	-	-	-	-

S= Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 15 Lake Granby - Transect at Sunset Point

Date	Yr/Mo/Day	74/06/11	74/06/12	74/06/13	74/06/11	74/06/12	74/06/13
Time	Mtly.	0815	0800	0745	0815	0800	0745
Depth		S	S	S	B	B	B
Temp.	Cent.	9.0	8.2	9.0	6.0	7.7	8.0
pH	SU	8.2	8.0	8.0	7.5	7.9	7.7
Conductivity	μ mhos	<50	60	59	<50	<50	58
DO	mg/l	9.1	9.1	9.0	8.3	8.7	8.6
TKN	mg/l	0.21	0.26	0.34	0.94	0.18	0.37
NO_2+NO_3-N	mg/l	<0.001	0.001	0.002	0.045	0.002	0.010
NH_3-N	mg/l	<0.002	0.009	<0.002	0.014	0.011	<0.002
Total-P	mg/l	0.012	0.016	0.015	0.268	0.017	0.028
Ortho-P	mg/l	0.001	0.007	0.002	0.011	0.007	0.002
Alkalinity	mg/l	22.7	22.7	22.7	24.7	22.7	22.7
Turbidity	JTU	0.81	0.71	0.82	17.0	0.73	1.4
T. Coli.	#/100ml	1	<1	2	-	-	-
F. Coli.	#/100ml	<1	<1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 16 Lake Granby - Transect at Rainbow Bay

Date	Yr/Mo/Day	74/06/11	74/06/12	74/06/13	74/06/11	74/06/12	74/06/13	74/06/11	74/06/12	74/06/13
Time	Mtly.	0720	0710	0705	0720	0710	0705	0720	0710	0705
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	8.0	9.0	9.5	6.0	6.5	8.5	5.0	5.0	6.0
pH	SU	8.1	8.1	7.7	7.8	7.6	8.1	7.5	7.5	7.5
Conductivity	μ mhos	61	60	67	60	<50	<50	<50	50	<50
DO	mg/l	9.6	9.1	9.2	8.2	8.8	9.1	7.8	7.6	7.6
TKN	mg/l	0.26	0.18	0.34	0.19	0.11	0.30	0.18	0.15	0.24
NO_2+NO_3-N	mg/l	<0.001	0.002	0.009	0.030	0.022	<0.001	0.058	0.052	0.044
NH_3-N	mg/l	<0.002	0.007	<0.002	0.007	0.012	<0.002	0.022	0.022	0.017
Total-P	mg/l	0.020	0.016	0.014	0.017	0.014	0.016	0.034	0.017	0.021
Ortho-P	mg/l	0.003	0.008	0.004	0.003	0.007	0.003	0.007	0.009	0.006
Alkalinity	mg/l	22.7	22.7	22.7	24.7	22.7	22.7	24.7	24.7	24.7
Turbidity	JTU	0.82	0.68	1.2	0.96	0.93	1.2	6.0	3.0	2.8
T. Coli.	#/100ml	1	<1	<1	-	-	-	-	-	-
F. Coli.	#/100ml	1	<1	<1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 17 Lake Granby - Transect at Kokanee Bay

Date	Yr/Mo/Day	74/06/11	74/06/12	74/06/13	74/06/11	74/06/12	74/06/13
Time	Mtly.	0705	0655	0650	0705	0655	0650
Depth		S	S	S	B	B	B
Temp.	Cent.	8.0	8.5	8.5	7.5	8.5	8.7
pH	SU	7.8	8.1	7.9	7.7	8.2	7.9
Conductivity	µ mhos	66	62	58	<50	63	<50
DO	mg/1	9.1	9.2	9.1	9.2	8.7	9.1
TKN	mg/1	0.18	0.16	0.22	0.24	0.16	0.29
NO_2+NO_3-N	mg/1	0.000	0.003	0.002	0.000	0.003	0.003
NH_3-N	mg/1	0.004	0.003	<0.002	0.003	0.012	0.009
Total-P	mg/1	0.016	0.021	0.012	0.018	0.018	0.013
Ortho-P	mg/1	0.002	0.014	0.003	0.003	0.009	0.004
Alkalinity	mg/1	24.7	22.7	22.7	26.8	22.7	22.7
Turbidity	JTU	0.91	0.71	1.2	2.0	0.88	1.5
T. Coli.	#/100ml	4	<1	1	-	-	-
F. Coli.	#/100ml	1	<1	1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 18 Lake Granby - Between Kokanee and Fish Bays

Date	Yr/Mo/Day	74/06/11	74/06/12	74/06/13	74/06/11	74/06/12	74/06/13
Time	Mtly.	0655	0640	0640	0655	0640	0640
Depth		S	S	S	B	B	B
Temp.	Cent.	7.0	9.0	8.0	6.5	9.0	8.5
pH	SU	8.0	8.0	8.1	7.5	8.1	8.2
Conductivity	µ mhos	55	58	62	68	60	<50
DO	mg/l	9.2	9.0	9.1	8.6	9.1	9.2
TKN	mg/l	0.16	0.17	0.27	0.21	0.24	0.19
NO_2+NO_3-N	mg/l	0.001	0.001	0.001	0.013	<0.001	0.001
NH_3-N	mg/l	0.003	0.011	<0.002	0.006	0.012	0.005
Total-P	mg/l	0.017	0.021	0.020	0.021	0.016	0.013
Ortho-P	mg/l	0.002	0.012	0.008	0.003	0.004	0.002
Alkalinity	mg/l	22.7	22.7	22.7	24.7	22.7	22.7
Turbidity	JTU	0.92	0.75	1.2	2.0	0.65	1.4
T. Coli.	#/100ml	<1	2	8	-	-	-
F. Coli.	#/100ml	<1	2	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 19 Lake Granby - Transect Fish Bay to Rainbow Island

Date	Yr/Mo/Day	74/06/11	74/06/12	74/06/13	74/06/11	74/06/12	74/06/13
Time	Mtly.	0640	0630	0625	0640	0630	0625
Depth		S	S	S	B	B	B
Temp.	Cent.	7.0	8.5	8.5	6.5	8.5	8.0
pH	SU	7.9	8.2	8.1	7.8	8.2	8.1
Conductivity	μ mhos	60	50	55	68	60	62
DO	mg/l	8.8	9.1	9.1	8.9	9.1	9.0
TKN	mg/l	0.24	0.20	0.26	0.25	0.21	0.25
NO_2+NO_3-N	mg/l	0.004	0.005	0.001	0.006	0.004	0.001
NH_3-N	mg/l	0.003	0.011	<0.002	0.004	0.008	<0.002
Total-P	mg/l	0.014	0.013	0.047	0.023	0.023	0.029
Ortho-P	mg/l	0.004	0.003	0.038	0.006	0.015	0.011
Alkalinity	mg/l	22.7	22.7	22.7	24.7	22.7	22.7
Turbidity	JTU	0.96	0.78	0.90	3.0	0.82	1.2
T. Coli.	#/100ml	2	1	<1	-	-	-
F. Coli.	#/100ml	2	<1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 20 Lake Granby - Transect Fish Bay to Rainbow Island

Date	Yr/Mo/Day	74/06/11	74/06/12	74/06/13	74/06/11	74/06/12	74/06/13	74/06/11	74/06/12	74/06/13
Time	Mtly.	0855	0825	0815	0855	0825	0815	0855	0825	0815
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	8.5	9.0	9.5	6.5	8.0	8.0	6.5	7.0	7.0
pH	SU	8.0	8.3	8.0	7.6	8.0	7.9	7.5	8.0	7.6
Conductivity	µ mhos	67	<50	50	60	<50	<50	<50	50	<50
DO	mg/l	8.9	9.1	9.0	8.3	8.4	8.1	8.3	8.3	8.2
TKN	mg/l	0.22	0.27	0.24	0.16	0.13	0.27	0.31	0.28	0.35
NO_2+NO_3-N	mg/l	0.001	<0.001	0.001	0.030	0.007	0.020	0.030	0.016	0.025
NH_3-N	mg/l	0.006	0.013	<0.002	0.009	0.015	<0.002	0.011	0.009	0.006
Total-P	mg/l	0.012	0.015	0.012	0.013	0.015	0.016	0.059	0.021	0.027
Ortho-P	mg/l	0.004	0.003	0.004	0.004	0.001	0.004	0.006	0.002	0.005
Alkalinity	mg/l	24.7	24.7	24.7	24.7	22.7	22.7	22.7	22.7	22.7
Turbidity	JTU	0.84	0.72	1.0	0.88	0.71	1.2	5.0	2.0	1.5
T. Coli.	#/100ml	1	2	10	-	-	-	-	-	-
F. Coli.	#/100ml	1	2	<1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 21 Lake Granby - Transect Fish Bay to Rainbow Island

Date	Yr/Mo/Day	74/06/11	74/06/12	74/06/13	74/06/11	74/06/12	74/06/13
Time	Mtly.	0845	0820	0800	0845	0820	0800
Depth		S	S	S	B	B	B
Temp.	Cent.	8.5	8.0	9.5	8.0	8.0	8.5
pH	SU	7.9	8.3	8.5	7.8	8.0	7.8
Conductivity	μ mhos	62	58	<50	60	<50	<50
DO	mg/l	8.9	8.8	9.2	8.5	8.9	8.6
TKN	mg/l	0.20	0.16	0.24	0.24	0.45	0.35
NO_2+NO_3-N	mg/l	0.002	0.001	0.002	0.003	0.002	0.003
NH_3-N	mg/l	0.005	0.009	<0.002	0.003	0.011	<0.002
Total-P	mg/l	0.023	0.016	0.013	0.021	0.042	0.023
Ortho-P	mg/l	0.005	0.004	0.004	0.005	0.006	0.006
Alkalinity	mg/l	26.8	20.6	22.7	24.7	22.7	22.7
Turbidity	JTU	1.0	0.69	1.1	0.91	6.0	1.2
T. Coli.	#/100ml	<1	<1	28	-	-	-
F. Coli.	#/100ml	<1	<1	1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 22 Lake Granby at Campground Launch Area

Date	Yr/Mo/Day	74/06/11	74/06/12	74/06/13
Time	Mtly.	0625	0620	0615
Depth		S	S	S
Temp.	Cent.	7.0	7.5	9.0
pH	SU	7.4	7.6	8.0
Conductivity	µ mhos	<50	<50	60
DO	mg/l	9.1	8.8	9.1
TKN	mg/l	0.18	0.27	0.30
NO_2+NO_3-N	mg/l	0.001	0.003	0.001
NH_3-N	mg/l	0.003	0.014	<0.002
Total-P	mg/l	0.300	0.016	0.125
Ortho-P	mg/l	0.289	0.003	0.118
Alkalinity	mg/l	24.7	24.7	24.7
Turbidity	JTU	0.95	0.72	1.0
T. Coli.	#/100ml	2	7	8
F. Coli.	#/100ml	<1	4	<1

S = Surface

THREE LAKES STUDY

Station: 23 Lake Granby at Cutthroat Trout Bay

Date	Yr/Mo/Day	74/06/11	74/06/12	74/06/13	74/06/11	74/06/12	74/06/13
Time	Mtly.	0915	0850	0830	0915	0850	0830
Depth		S	S	S	S	S	S
Temp.	Cent.	9.0	8.5	8.0	6.0	8.5	7.0
pH	SU	8.4	8.0	7.9	7.3	7.8	7.5
Conductivity	µ mhos	<50	<50	62	<50	<50	62
DO	mg/1	8.9	9.0	9.0	7.7	8.7	8.2
TKN	mg/1	0.24	0.11	0.40	0.27	0.16	0.83
NO_2+NO_3-N	mg/1	<0.001	0.003	0.001	0.029	0.002	0.013
NH_3-N	mg/1	0.010	0.022	<0.002	0.011	0.011	<0.002
Total-P	mg/1	0.024	0.014	0.014	0.023	0.022	0.114
Ortho-P	mg/1	0.006	0.002	0.009	0.007	0.004	0.011
Alkalinity	mg/1	26.8	22.7	22.7	24.7	22.7	22.7
Turbidity	JTU	2.0	0.68	1.2	3.0	0.96	4.0
T. Coli.	#/100ml	60	16	23	-	-	-
F. Coli.	#/100ml	44	7	2	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 27 Shadow Mt. Lake - Transect at South End of Lake

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	0640	0725	0730
Depth		S	S	S
Temp.	Cent.	10	11	11
pH	SU	7.6	7.7	7.6
Conductivity	μmhos	<50	52	<50
DO	mg/l	8.3	8.0	7.7
TKN	mg/l	0.41	0.27	0.32
NO_2+NO_3-N	mg/l	<0.001	0.001	0.001
NH_3-N	mg/l	<0.002	<0.002	0.004
Total-P	mg/l	0.010	0.017	0.019
Ortho-P	mg/l	0.002	0.002	0.003
Alkalinity	mg/l	16.5	18.5	14.4
Turbidity	JTU	2.3	2.6	2.4
T. Coli.	#/100ml	8	23	9
F. Coli.	#/100ml	8	3	1

S = Surface

THREE LAKES STUDY

Station: 28 Shadow Mt. Lake - Transect at South End of Lake

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16	74/06/14	74/06/15	74/06/16
Time	Mtly.	0630	0715	0720	0630	0715	0720
Depth		S	S	S	B	B	B
Temp.	Cent.	10	11.5	11.0	7.5	10	10.5
pH	SU	7.7	7.8	7.8	7.6	7.4	7.6
Conductivity	μ mhos	<50	<50	<50	<50	<50	<50
DO	mg/l	8.6	8.1	8.4	6.7	7.3	7.8
TKN	mg/l	0.51	0.37	0.28	0.36	0.65	1.6
NO_2+NO_3-N	mg/l	0.002	0.003	0.001	<0.001	<0.001	0.001
NH_3-N	mg/l	<0.002	<0.002	<0.002	<0.002	0.002	0.004
Total-P	mg/l	0.106	0.016	0.033	0.026	0.104	0.240
Ortho-P	mg/l	0.102	0.002	0.003	0.009	0.005	0.016
Alkalinity	mg/l	16.5	16.5	14.4	18.5	16.5	14.4
Turbidity	JTU	2.0	2.3	2.2	3.8	3.7	16
T. Coli.	#/100ml	4	16	8	-	-	-
F. Coli.	#/100ml	4	<1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 29 Shadow Mt. Lake - Transect at South End of Lake

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	0630	0710	0715
Depth		S	S	S
Temp.	Cent.	10.5	10.5	11.0
pH	SU	7.5	7.6	7.8
Conductivity	μ mhos	<50	<50	<50
DO	mg/l	8.5	8.2	8.2
TKN	mg/l	0.39	0.37	0.72
NO_2+NO_3-N	mg/l	0.002	<0.001	0.001
NH_3-N	mg/l	<0.002	<0.002	<0.002
Total-P	mg/l	0.009	0.016	0.071
Ortho-P	mg/l	0.004	0.002	0.005
Alkalinity	mg/l	16.5	16.5	14.4
Turbidity	JTU	1.8	2.0	2.2
T. Coli.	#/100ml	<1	14	2
F. Coli.	#/100ml	<1	<1	1

S = Surface

THREE LAKES STUDY

Station: 32 Shadow Mt. Lake - Transect at North Side of Islands

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	0645	0730	0735
Depth		S	S	S
Temp.	Cent.	9.5	10	11
pH	SU	7.8	7.5	7.7
Conductivity	μ mhos	<50	<50	<50
DO	mg/l	8.2	8.1	8.1
TKN	mg/l	0.31	0.84	0.20
NO_2+NO_3-N	mg/l	0.003	0.003	0.002
NH_3-N	mg/l	<0.002	0.004	<0.002
Total-P	mg/l	0.012	0.023	0.021
Ortho-P	mg/l	0.005	0.004	0.006
Alkalinity	mg/l	14.4	16.5	12.4
Turbidity	JTU	3.3	4.5	3.2
T. Coli.	#/100ml	100	170	39
F. Coli.	#/100ml	36	22	21

S = Surface

THREE LAKES STUDY

Station: 33 Shadow Mt. Lake - Transect at North Side of Islands

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16	74/06/14	74/06/15	74/06/16
Time	Mtly.	0655	0735	0740	0655	0735	0740
Depth		S	S	S	B	B	B
Temp.	Cent.	10	11.5	11	9.5	10.5	10
pH	SU	7.6	7.8	7.5	7.3	7.6	7.7
Conductivity	µmhos	<50	<50	<50	<50	<50	<50
DO	mg/l	8.5	8.1	8.3	8.4	8.1	8.6
TKN	mg/l	0.27	0.41	0.32	0.59	0.49	0.28
NO_2+NO_3-N	mg/l	0.001	0.004	<0.001	0.001	0.002	0.001
NH_3-N	mg/l	0.008	<0.002	<0.002	<0.002	0.003	<0.002
Total-P	mg/l	0.009	0.018	0.018	0.082	0.042	0.035
Ortho-P	mg/l	0.002	0.003	0.005	0.007	0.005	0.005
Alkalinity	mg/l	16.5	16.5	14.4	16.5	16.5	12.4
Turbidity	JTU	1.8	1.9	1.8	6.6	5.6	3.3
T. Coli.	#/100ml	3	4	9	-	-	-
F. Coli.	#/100ml	3	<1	5	-	-	-

S = Surface M = Thermocline B = Bottom

Station: 34 Shadow Mt. Lake - Transect at North Side of Islands

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	0710	0745	0750
Depth		S	S	S
Temp.	Cent.	10	11.5	11.5
pH	SU	7.7	7.7	7.6
Conductivity	µmhos	<50	<50	<50
DO	mg/1	8.8	8.2	8.1
TKN	mg/1	0.35	0.64	0.30
NO_2+NO_3-N	mg/1	<0.001	0.001	<0.001
NH_3-N	mg/1	<0.002	0.003	<0.002
Total-P	mg/1	0.015	0.044	0.024
Ortho-P	mg/1	0.004	0.004	0.005
Alkalinity	mg/1	16.5	16.5	12.4
Turbidity	JTU	2.0	2.4	2.0
T. Coli.	#/100ml	12	6	3
F. Coli.	#/100ml	3	<1	3

S = Surface

THREE LAKES STUDY

Station: 35 Shadow Mt. Lake - At Boat Docks West Side of Lake

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	0835	0845	0815
Depth		S	S	S
Temp.	Cent.	11	12	11
pH	SU	7.5	7.5	7.3
Conductivity	μmhos	<50	<50	<50
DO	mg/l	8.3	8.2	7.9
TKN	mg/l	0.35	0.31	0.38
NO_2+NO_3-N	mg/l	0.002	0.001	<0.001
NH_3-N	mg/l	0.003	0.011	<0.002
Total-P	mg/l	0.010	0.018	0.022
Ortho-P	mg/l	0.003	0.003	0.005
Alkalinity	mg/l	18.5	16.5	16.5
Turbidity	JTU	1.8	1.8	2.1
T. Coli.	#/100ml	<1	<1	5
F. Coli.	#/100ml	<1	<1	4

S = Surface

THREE LAKES STUDY

Station:	36	Shadow Mt. Lake - Transect at Center of Lake		
Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	0740	0806	0810
Depth		S	S	S
Temp.	Cent.	11	11	11
pH	SU	7.6	7.7	7.5
Conductivity	µ mhos	<50	<50	<50
DO	mg/1	8.5	8.2	8.3
TKN	mg/1	0.34	0.44	0.39
NO_2+NO_3-N	mg/1	0.001	0.003	0.001
NH_3-N	mg/1	0.007	<0.002	0.013
Total-P	mg/1	0.009	0.030	0.031
Ortho-P	mg/1	0.003	0.003	0.005
Alkalinity	mg/1	16.5	14.4	12.4
Turbidity	JTU	1.7	2.0	1.6
T. Coli.	#/100ml	4	15	4
F. Coli.	#/100ml	<1	11	3

S = Surface

THREE LAKES STUDY

Station: 37 Shadow Mt. Lake - Transect at Center of Lake

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16	74/06/14	74/06/15	74/06/16
Time	Mtly.	0735	0755	0805	0735	0755	0805
Depth		S	S	S	B	B	B
Temp.	Cent.	10	10.5	11	9.0	10.5	9.0
pH	SU	7.7	7.8	7.5	7.3	7.3	7.6
Conductivity	μ mhos	<50	<50	<50	<50	<50	<50
DO	mg/l	8.4	8.4	8.4	7.8	7.9	8.9
TKN	mg/l	0.28	0.37	0.32	1.30	2.5	0.26
NO_2+NO_3-N	mg/l	<0.001	0.005	<0.001	0.001	0.008	0.019
NH_3-N	mg/l	<0.002	<0.002	<0.002	0.020	0.045	<0.002
Total-P	mg/l	0.007	0.021	0.018	0.186	0.382	0.019
Ortho-P	mg/l	0.003	0.001	0.005	0.012	0.013	0.005
Alkalinity	mg/l	18.5	16.5	14.4	16.5	14.4	12.4
Turbidity	JTU	1.8	1.7	1.9	17.0	18	1.4
T. Coli.	#/100ml	4	29	7	-	-	-
F. Coli.	#/100ml	<1	9	5	-	-	-

S = Surface   M = Thermocline   B = Bottom

THREE LAKES STUDY

Station: 38 Shadow Mt. Lake - Transect at Center of Lake

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	0725	0750	0755
Depth		S	S	S
Temp.	Cent.	10	10	11
pH	SU	7.7	7.8	7.6
Conductivity	µ mhos	<50	<50	<50
DO	mg/l	8.0	7.6	7.9
TKN	mg/l	0.31	0.31	0.28
NO_2+NO_3-N	mg/l	<0.001	0.001	0.003
NH_3-N	mg/l	<0.002	0.023	<0.002
Total-P	mg/l	0.039	0.029	0.013
Ortho-P	mg/l	0.005	0.003	0.005
Alkalinity	mg/l	14.4	18.5	14.4
Turbidity	mg/l	2.0	2.3	2.0
T. Coli.	#/100ml	4	16	3
F. Coli.	#/100ml	1	2	<1

S = Surface

THREE LAKES STUDY

Station: 39 Shadow Mt. Lake - At Boat Docks West Side of Lake

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	0750	0810	0815
Depth		S	S	S
Temp.	Cent.	11	10	11
pH	SU	7.6	7.5	7.5
Conductivity	μ mhos	<50	<50	<50
DO	mg/1	8.3	8.6	8.4
TKN	mg/1	0.34	0.28	0.30
NO_2+NO_3-N	mg/1	0.001	0.003	0.002
NH_3-N	mg/1	0.011	<0.002	<0.002
Total-P	mg/1	0.015	0.020	0.011
Ortho-P	mg/1	0.004	0.002	0.005
Alkalinity	mg/1	16.5	16.5	14.4
Turbidity	JTU	1.8	2.0	1.6
T. Coli.	#/100ml	5	20	19
F. Coli.	#/100ml	2	9	12

S = Surface

THREE LAKES STUDY

Station: 40 Shadow Mt. Lake - Transect at North End of Lake

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	0800	0815	0820
Depth		S	S	S
Temp.	Cent.	10	10	9.0
pH	SU	7.6	7.4	7.3
Conductivity	µ mhos	<50	<50	<50
DO	mg/l	8.6	8.9	8.7
TKN	mg/l	0.37	0.32	0.23
NO_2+NO_3-N	mg/l	0.003	0.015	0.020
NH_3-N	mg/l	<0.002	0.005	0.047
Total-P	mg/l	0.013	0.024	0.010
Ortho-P	mg/l	0.004	0.001	0.004
Alkalinity	mg/l	14.4	12.4	10.3
Turbidity	JTU	1.5	1.3	0.82
T. Coli.	#/100ml	30	90	11
F. Coli.	#/100ml	23	70	9

S = Surface

THREE LAKES STUDY

Station: 41 Shadow Mt. Lake - Transect at North End of Lake

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16	74/06/14	74/06/15	74/06/16
Time	Mtly.	0810	0820	0830	0810	0820	0830
Depth		S	S	S	B	B	B
Temp.	Cent.	11	11	10.5	8.5	8.0	10.5
pH	SU	7.6	7.4	7.4	7.4	7.2	7.4
Conductivity	µ mhos	<50	<50	<50	<50	<50	<50
DO	mg/1	8.3	8.6	8.6	8.9	8.9	8.6
TKN	mg/1	0.40	0.19	0.23	0.29	-	0.42
NO_2+NO_3-N	mg/1	0.001	0.015	0.009	0.024	0.030	0.022
NH_3-N	mg/1	<0.002	<0.002	<0.002	<0.002	0.007	<0.002
Total-P	mg/1	0.013	0.014	0.017	0.041	0.027	0.040
Ortho-P	mg/1	0.004	0.001	0.005	0.004	0.002	0.008
Alkalinity	mg/1	14.4	12.4	12.4	12.4	11.3	10.3
Turbidity	JTU	1.5	1.3	1.5	0.8	7.9	5.8
T. Coli.	#/100ml	12	57	10	-	-	-
F. Coli.	#/100ml	10	28	8	-	-	-

S = Surface

THREE LAKES STUDY

Station: 42 Shadow Mt. Lake - Transect at North End of Lake

Date	Yr/Mo/Day	74/06/14	74/06/15	74/06/16
Time	Mtly.	0820	0825	0835
Depth		S	S	S
Temp.	Cent.	11	11.5	11
pH	SU	7.5	7.4	7.4
Conductivity	µ mhos	<50	<50	<50
DO	mg/l	8.1	8.3	8.0
TKN	mg/l	0.52	0.59	0.38
NO_2+NO_3-N	mg/l	0.002	0.001	0.001
NH_3-N	mg/l	<0.002	<0.002	0.055
Total-P	mg/l	0.068	0.027	0.015
Ortho-P	mg/l	0.004	0.003	0.005
Alkalinity	mg/l	16.5	16.5	14.4
Turbidity	JTU	1.6	2.1	1.9
T. Coli.	#/100ml	7	16	3
F. Coli.	#/100ml	7	12	3

S = Surface

THREE LAKES STUDY

Station: 45 Grand Lake at Outlet Between Lakes

Date	Yr/Mo/Day	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19
Time	Mtly.	0745	0720	0745	0745	0720	
Depth		S	S	S	B	B	B
Temp.	Cent.	7.5	6.5	7.0	7.0	6.5	
pH	SU	7.5	7.4	7.1	7.4	7.5	
Conductivity	μ mhos	<50	<50	<50	<50	<50	
DO	mg/1	9.0	9.0	8.9	8.9	8.9	NO SAMPLE
TKN	mg/1	0.22	0.27	0.54	0.30	-	
NO_2+NO_3-N	mg/1	0.027	0.027	0.028	0.034	-	
NH_3-N	mg/1	<0.002	<0.002	<0.002	0.008	-	
Total-P	mg/1	0.009	0.013	0.004	0.061	-	
Ortho-P	mg/1	0.005	0.003	0.001	0.042	-	
Alkalinity	mg/1	10.3	10.3	10.3	10.3	10.3	
Turbidity	JTU	0.68	7.8	0.58	0.68	0.65	
T. Coli.	#/100ml	10	4	5	-	-	
F. Coli.	#/100ml	1	4	4	-	-	

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 46 Grand Lake - Transect at West End of Lake

Date	Yr/Mo/Day	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19
Time	Mtly.	0750	0725	0750	0750	0725	0750
Depth		S	S	S	B	B	B
Temp.	Cent.	7.0	6.5	7.0	7.5	6.5	6.5
pH	SU	7.2	7.5	7.2	7.4	7.3	7.1
Conductivity	µ mhos	<50	<50	<50	<50	<50	<50
DO	mg/l	9.0	8.9	8.9	9.0	8.8	9.0
TKN	mg/l	0.20	0.22	0.79	0.29	0.22	0.45
NO_2+NO_3-N	mg/l	0.028	0.028	0.025	0.028	0.028	0.030
NH_3-N	mg/l	<0.002	<0.002	0.004	<0.002	<0.002	0.007
Total-P	mg/l	0.011	0.010	0.005	0.017	0.019	0.019
Ortho-P	mg/l	0.006	0.003	0.001	0.007	0.004	0.010
Alkalinity	mg/l	10.3	10.3	10.3	10.3	12.4	10.3
Turbidity	JTU	0.64	0.65	0.56	0.61	0.66	0.74
T. Coli.	#/100ml	2	7	2	-	-	-
F. Coli.	#/100ml	2	2	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 47 Grand Lake - Transect at West End of Lake

Date	Yr/Mo/Day	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19
Time	Mtly.	0800	0735	0755	0800	0735	0755	0800	0735	0755
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	7.0	7.0	7.5	6.0	6.0	6.0	5.0	5.0	5.0
pH	SU	7.2	7.2	7.1	7.1	7.4	7.1	7.1	7.2	7.1
Conductivity	μ mhos	<50	<50	<50	<50	<50	<50	<50	<50	<50
DO	mg/l	9.0	8.9	8.9	8.9	8.9	8.6	8.1	8.7	8.7
TKN	mg/l	0.26	0.21	0.50	0.24	0.23	0.37	0.38	0.21	0.50
NO_2+NO_3-N	mg/l	0.028	0.029	0.027	0.037	0.033	0.039	0.048	0.039	0.045
NH_3-N	mg/l	<0.002	<0.002	<0.002	0.016	<0.002	0.004	0.008	0.004	0.004
Total-P	mg/l	0.009	0.013	0.005	0.013	0.015	0.015	0.065	0.016	0.013
Ortho-P	mg/l	0.003	0.003	0.001	0.004	0.003	0.007	0.005	0.003	0.005
Alkalinity	mg/l	10.3	12.4	10.3	12.4	10.3	12.4	12.4	10.3	14.4
Turbidity	JTU	0.58	0.85	0.63	0.68	0.61	1.6	2.3	0.62	0.76
T. Coli.	#/100ml	6	1	2	-	-	-	-	-	-
F. Coli.	#/100ml	1	1	1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 48 Grand Lake - Transect at West End of Lake

Date	Yr/Mo/Day	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19
Time	Mtly.	0820	0750	0800	0820	0750	0800
Depth		S	S	S	B	B	B
Temp.	Cent.	7.5	6.5	7.5	7.0	6.6	7.5
pH	SU	7.1	7.2	7.2	7.2	7.1	7.2
Conductivity	µmhos	<50	<50	<50	<50	<50	<50
DO	mg/l	8.9	8.9	9.0	8.9	9.0	8.9
TKN	mg/l	0.25	0.19	0.35	0.45	0.22	0.44
NO_2+NO_3-N	mg/l	0.023	0.030	0.028	0.030	0.030	0.031
NH_3-N	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Total-P	mg/l	0.011	0.012	0.007	0.085	0.013	0.011
Ortho-P	mg/l	0.001	0.003	0.001	0.008	0.003	0.004
Alkalinity	mg/l	12.4	10.3	10.3	10.3	10.3	10.3
Turbidity	JTU	0.61	0.57	0.50	3.0	5.2	0.58
T. Coli.	#/100ml	6	11	2	-	-	-
F. Coli.	#/100ml	1	5	1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 49 Grand Lake - Transect at Center of Lake

Date	Yr/Mo/Day	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19
Time	Mtly.	0910	0835	0900	0910	0835	0900
Depth		S	S	S	B	B	B
Temp.	Cent.	7.0	7.5	9.0	7.5	7.0	6.5
pH	SU	7.0	7.1	7.3	7.1	7.0	7.2
Conductivity	μ mhos	<50	<50	<50	<50	<50	<50
DO	mg/l	8.9	9.0	8.8	8.9	8.9	8.8
TKN	mg/l	0.23	0.37	0.63	0.24	0.26	0.34
NO_2+NO_3-N	mg/l	0.026	0.029	0.026	0.028	0.032	0.032
NH_3-N	mg/l	0.003	<0.002	<0.002	0.008	<0.002	<0.002
Total-P	mg/l	0.024	0.029	0.007	0.013	0.015	0.007
Ortho-P	mg/l	0.001	0.003	0.001	0.001	0.002	0.001
Alkalinity	mg/l	10.3	10.3	10.3	10.3	10.3	12.4
Turbidity	JTU	0.55	0.54	0.62	0.68	0.66	0.77
T. Coli.	#/100ml	3	5	3	-	-	-
F. Coli.	#/100ml	2	4	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 50 Grand Lake - Transect at Center of Lake

Date	Yr/Mo/Day	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19
Time	Mtly.	0855	0820	0845	0855	0820	0845	0855	0820	0845
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	8.0	7.5	9.0	5.5	5.0	6.0	4.0	3.5	4.5
pH	SU	7.0	7.2	7.2	7.0	7.2	7.1	7.0	7.0	7.0
Conductivity	μmhos	<50	<50	<50	<50	<50	<50	<50	50	50
DO	mg/l	9.0	9.2	9.0	8.7	8.5	8.7	6.6	5.5	5.9
TKN	mg/l	0.26	0.22	0.48	0.19	0.18	0.46	0.27	0.68	0.48
NO_2+NO_3-N	mg/l	0.026	0.028	0.025	0.040	0.040	0.039	0.085	0.083	0.092
NH_3-N	mg/l	0.006	<0.002	<0.002	<0.002	0.007	0.002	0.042	0.075	0.018
Total-P	mg/l	0.110	0.040	0.006	0.058	0.038	0.008	0.027	0.171	0.009
Ortho-P	mg/l	0.001	0.002	0.002	0.001	0.002	0.003	0.003	0.010	0.004
Alkalinity	mg/l	10.3	10.3	10.3	10.3	12.4	12.4	18.5	18.5	18.5
Turbidity	JTU	0.57	0.59	0.54	0.56	0.65	0.64	1.5	9.6	1.3
T. Coli.	#/100ml	1	17	2	-	-	-	-	-	-
F. Coli.	#/100ml	1	6	2	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 51 Grand Lake - Transect at Center of Lake

Date	Yr/Mo/Day	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19
Time	Mtly.	0840	0810	0830	0840	0810	0830	0840	0810	0830
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	8.0	7.0	8.0	6.0		6.5	6.0	6.0	6.0
pH	SU	7.1	7.1	7.0	7.0		6.9	6.9	7.0	7.0
Conductivity	µmhos	<50	<50	<50	<50		<50	<50	<50	<50
DO	mg/1	9.1	8.8	9.0	8.7		8.9	8.6	9.0	8.8
TKN	mg/1	0.30	0.30	0.47	0.24	NO SAMPLE	0.15	0.18	0.25	0.47
NO_2+NO_3-N	mg/1	0.026	0.029	0.025	0.041		0.033	0.042	0.033	0.033
NH_3-N	mg/1	<0.002	0.002	0.003	0.004		<0.002	0.002	0.005	<0.002
Total-P	mg/1	0.012	0.086	0.007	0.019		0.011	0.012	0.061	0.008
Ortho-P	mg/1	0.001	0.003	0.002	0.001		0.001	0.007	0.003	0.001
Alkalinity	mg/1	10.3	10.3	10.3	12.4		10.3	12.4	10.3	10.3
Turbidity	JTU	0.56	0.54	0.53	0.54		0.77	0.56	0.76	0.58
T. Coli.	#/100ml	3	3	3	-		-	-	-	-
F. Coli.	#/100ml	1	2	3	-		-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 53 Grand Lake - Transect at East End of Lake

Date	Yr/Mo/Day	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19
Time	Mtly.	0925	0845	0905	0925	0845	0905
Depth		S	S	S	B	B	B
Temp.	Cent.	8.0	8.0	8.0	6.0	6.0	6.0
pH	SU	7.1	7.1	7.0	7.0	7.2	7.0
Conductivity	µmhos	<50	<50	<50	<50	<50	<50
DO	mg/l	9.2	8.8	9.0	9.2	9.3	9.1
TKN	mg/l	0.30	0.28	0.38	0.61	0.23	0.35
NO_2+NO_3-N	mg/l	0.028	0.029	0.029	0.030	0.027	0.046
NH_3-N	mg/l	0.013	0.004	<0.002	<0.002	0.008	<0.002
Total-P	mg/l	0.009	0.040	0.008	0.016	0.049	0.015
Ortho-P	mg/l	0.001	0.003	0.002	0.006	0.002	0.002
Alkalinity	mg/l	10.3	10.3	10.3	10.3	10.3	10.3
Turbidity	JTU	0.50	0.54	0.54	0.58	0.56	0.67
T. Coli.	#/100ml	3	7	4	-	-	-
F. Coli.	#/100ml	2	4	1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 54 Grand Lake - Transect at East End of Lake

Date	Yr/Mo/Day	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19
Time	Mtly.	0930	0855	0915	0930	0855	0915	0930	0855	0915
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	7.5	8.5	10	6.5	6.5	6.5	4.0	4.5	4.0
pH	SU	7.0	7.2	7.3	6.9	7.1	6.9	6.9	7.1	6.9
Conductivity	μmhos	<50	<50	<50	<50	<50	<50	<50	<50	<50
DO	mg/1	8.8	8.9	8.9	9.0	8.9	8.9	6.8	6.9	7.0
TKN	mg/1	-	0.22	0.31	0.24	0.26	0.82	0.40	0.59	0.50
NO_2+NO_3-N	mg/1	0.026	0.025	0.026	0.031	0.034	0.039	0.081	0.084	0.082
NH_3-N	mg/1	<0.002	<0.002	0.004	<0.002	0.003	0.005	0.011	0.020	0.005
Total-P	mg/1	0.006	0.031	0.008	0.011	0.047	0.008	0.018	0.126	0.044
Ortho-P	mg/1	0.002	0.002	0.002	0.002	0.002	0.012	0.007	0.009	0.007
Alkalinity	mg/1	10.3	10.3	10.3	12.4	10.3	10.3	20.6	18.5	20.6
Turbidity	JTU	0.55	0.58	0.52	0.58	0.52	0.57	0.75	5.9	3.2
T. Coli.	#/100ml	1	<1	2	-	-	-	-	-	-
F. Coli.	#/100ml	<1	<1	2	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 55 Grand Lake - Transect at East End of Lake

Date	Yr/Mo/Day	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19
Time	Mtly.	0945	0910	0930	0945	0910	0930
Depth		S	S	S	B	B	B
Temp.	Cent.	8.0	8.5	8.0	7.0	6.5	6.5
pH	SU	7.0	7.2	7.0	7.0	7.1	6.9
Conductivity	μmhos	<50	<50	<50	<50	<50	<50
DO	mg/1	9.0	9.0	9.1	8.8	9.0	8.8
TKN	mg/1	0.24	0.28	0.25	0.18	0.34	0.32
NO_2+NO_3-N	mg/1	0.024	0.025	0.031	0.029	0.029	0.033
NH_3-N	mg/1	<0.002	0.003	<0.002	<0.002	0.007	<0.002
Total-P	mg/1	0.010	0.065	0.009	0.013	0.043	0.009
Ortho-P	mg/1	0.002	0.003	0.005	0.002	0.003	0.002
Alkalinity	mg/1	10.3	10.3	10.3	10.3	10.3	10.3
Turbidity	JTU	0.53	0.61	0.56	0.49	0.56	0.51
T. Coli.	#/100ml	4	2	2	-	-	-
F. Coli.	#/100ml	3	1	2	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 56 Grand Lake - Inlet to Adams Tunnel

Date	Yr/Mo/Day	74/06/17	74/06/18	74/06/19	74/06/17	74/06/18	74/06/19
Time	Mtly.	0950	0920	0935	0950	0920	0935
Depth		S	S	S	B	B	B
Temp.	Cent.	8.0	8.5	9.0	7.0	7.0	7.0
pH	SU	7.0	7.1	7.1	6.9	7.1	7.1
Conductivity	µmhos	<50	<50	<50	<50	<50	<50
DO	mg/l	9.1	8.7	8.7	9.1	9.0	9.1
TKN	mg/l	0.20	0.51	0.50	0.20	0.44	0.42
NO_2+NO_3-N	mg/l	0.025	0.025	0.029	0.024	0.032	0.032
NH_3-N	mg/l	<0.002	0.002	<0.002	<0.002	0.003	0.003
Total-P	mg/l	0.012	0.045	0.009	0.011	0.046	0.009
Ortho-P	mg/l	0.002	0.002	0.002	0.002	0.001	0.002
Alkalinity	mg/l	10.3	10.3	10.3	10.3	10.3	10.3
Turbidity	JTU	0.49	0.56	0.56	0.53	0.61	0.77
T. Coli.	#/100ml	19	2	<1	-	-	-
F. Coli.	#/100ml	6	2	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 1 Arapaho Creek at Lake Granby

Date	Yr/Mo/Day	74/09/04	74/09/05	74/09/06
Time	Mtly.	0830	0800	0815
Temp.	Cent.	12.5	13.0	12.5
Flow	m^3/s	-	-	0.54
pH	SU	7.1	7.2	7.1
Conductivity	μ mhos	47	50	47
DO	mg/l	7.2	7.4	7.4
BOD_5	mg/l	1.4	1.8	1.7
TKN	mg/l	0.50	0.34	0.38
NO_2+NO_3-N	mg/l	0.004	0.004	0.005
NH_3-N	mg/l	0.026	0.020	0.025
Total-P	mg/l	0.019	0.022	0.019
Ortho-P	mg/l	0.002	0.005	0.003
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	1.4	1.6	1.7
Alkalinity	mg/l	37.4	41.6	37.4
Suspended Solids	mg/l	2	2.5	3
T. Coli.	#/100ml	<2	18	<1
F. Coli.	#/100ml	<2	10	<1

THREE LAKES STUDY

Station: 3 Roaring Fork at Lake Granby

Date	Yr/Mo/Day	74/09/04	74/09/05	74/09/06
Time	Mtly.	0850	0830	0835
Temp.	Cent.	4.0	4.5	5.0
Flow	m^3/s	-	-	0.08
pH	SU	7.3	7.5	7.4
Conductivity	µmhos	42	43	42
DO	mg/l	9.5	9.4	9.4
BOD_5	mg/l	1.0	<1	1.0
TKN	mg/l	0.14	0.03	0.03
NO_2+NO_3-N	mg/l	0.014	0.017	0.014
NH_3-N	mg/l	0.019	0.017	0.013
Total-P	mg/l	0.006	0.008	0.004
Ortho-P	mg/l	0.001	0.002	<0.001
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	0.13	0.18	0.17
Alkalinity	mg/l	35.4	41.6	35.4
Suspended Solids	mg/l	<1	<1	<1
T. Coli.	#/100ml	2	6	11
F. Coli.	#/100ml	<2	6	2

THREE LAKES STUDY

Station: 11 Twin Creek at Lake Granby

Date	Yr/Mo/Day	74/09/04	74/09/05	74/09/06
Time	Mtly.	1110	1025	1040
Temp.	Cent.	12.0	6.5	7.0
Flow	m^3/s	-	0.02	-
pH	SU	6.8	7.3	7.2
Conductivity	μmhos	36	44	43
DO	mg/l	8.9	9.0	9.0
BOD_5	mg/l	<1	<1	1.0
TKN	mg/l	0.16	0.10	0.14
NO_2+NO_3-N	mg/l	<0.001	0.003	0.004
NH_3-N	mg/l	0.020	0.024	0.009
Total-P	mg/l	0.006	0.010	0.007
Ortho-P	mg/l	0.001	0.003	<0.001
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	0.46	0.42	0.37
Alkalinity	mg/l	37.4	41.6	35.4
Suspended Solids	mg/l	<1	2	<1
T. Coli.	#/100ml	4	4	3
F. Coli	#/100ml	<2	<1	1

THREE LAKES STUDY

Station: 12 Columbine Creek at Lake Granby

Date	Yr/Mo/Day	74/09/04	74/09/05	74/09/06
Time	Mtly.	1130	1110	1100
Temp.	Cent.	6.5	7.0	7.0
Flow	m^3/s	-	0.06	-
pH	SU	6.6	7.0	7.0
Conductivity	µmhos	36	37	38
DO	mg/l	8.9	9.0	9.1
BOD_5	mg/l	1.0	<1	1.1
TKN	mg/l	0.17	0.16	0.14
NO_2+NO_3-N	mg/l	0.001	0.003	0.004
NH_3-N	mg/l	0.009	0.023	0.023
Total-P	mg/l	0.004	0.006	0.004
Ortho-P	mg/l	<0.001	0.001	<0.001
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	0.46	0.41	0.31
Alkalinity	mg/l	35.4	35.4	39.6
Suspended Solids	mg/l	1	<1	<1
T. Coli.	#/100ml	8	4	11
F. Coli.	#/100ml	4	4	5

THREE LAKES STUDY

Station: 24 Stillwater Creek near Lake Granby

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11
Time	Mtly.	1200	1145	1105
Temp.	Cent.	15.0	14.0	14.0
Flow	m^3/s	-	0.05	-
pH	SU	8.0	8.7	7.8
Conductivity	μmhos	203	215	203
DO	mg/l	8.9	8.7	8.7
BOD_5	mg/l	1.4	2.1	1.8
TKN	mg/l	0.28	0.48	0.50
NO_2+NO_3-N	mg/l	0.091	0.092	0.085
NH_3-N	mg/l	0.032	0.036	0.034
Total-P	mg/l	0.127	0.122	0.116
Ortho-P	mg/l	0.097	0.096	0.093
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	2.4	2.5	2.5
Alkalinity	mg/l	164	173	160
Suspended Solids	mg/l	3	4	5
T. Coli.	#/100ml	160	200	400
F. Coli.	#/100ml	100	140	270

THREE LAKES STUDY

Station: 24-A Stillwater Creek at Arapaho National Forest

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11
Time	Mtly.	1220	1230	1130
Temp.	Cent.	12.0	12.0	12.0
Flow	m^3/s	-	0.03	-
pH	SU	7.1	7.4	7.3
Conductivity	μmhos	79	82	81
DO	mg/l	8.2	8.2	8.2
BOD_5	mg/l	1.6	<1	<1
TKN	mg/l	0.06	0.23	0.13
NO_2+NO_3-N	mg/l	0.011	0.009	0.009
NH_3-N	mg/l	0.030	0.019	0.018
Total-P	mg/l	0.072	0.068	0.066
Ortho-P	mg/l	0.063	0.064	0.064
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	0.72	0.56	0.45
Alkalinity	mg/l	47.8	47.8	47.8
Suspended Solids	mg/l	1	2	3
T. Coli.	#/100ml	<1	12	<1
F. Coli.	#/100ml	<1	2	<1

THREE LAKES STUDY

Station: 25 Soda Creek near Granby Lake

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11
Time	Mtly.	1300	1330	1215
Temp.	Cent.	16.0	16.5	15.0
Flow	m^3/s	-	0.001	-
pH	SU	7.3	7.6	7.4
Conductivity	μmhos	215	215	215
DO	mg/l	8.1	7.8	7.5
BOD_5	mg/l	2.9	3.2	2.9
TKN	mg/l	0.67	1.26	0.82
NO_2+NO_3-N	mg/l	0.007	0.008	0.008
NH_3-N	mg/l	0.052	0.042	0.040
Total-P	mg/l	0.177	0.237	0.176
Ortho-P	mg/l	0.114	0.135	0.113
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	9.3	80.0	13.0
Alkalinity	mg/l	183	185	183
Suspended Solids	mg/l	22	33	39
T. Coli.	#/100ml	44	240	120
F. Coli.	#/100ml	26	130	12

THREE LAKES STUDY

Station: 25-A Soda Creek at Arapaho National Forest

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11
Time	Mtly.	1235	1300	1145
Temp.	Cent.	15.0	15.0	13.0
Flow	m^3/s	-	0.005	-
pH	SU	7.1	7.3	7.6
Conductivity	μmhos	79	88	85
DO	mg/l	7.6	7.7	7.9
BOD_5	mg/l	<1	<1	1.6
TKN	mg/l	0.24	0.54	0.54
NO_2+NO_3-N	mg/l	0.005	0.007	0.005
NH_3-N	mg/l	0.031	0.030	0.023
Total-P	mg/l	0.045	0.040	0.042
Ortho-P	mg/l	0.029	0.033	0.029
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	2.6	3.0	3.0
Alkalinity	mg/l	58.2	60.4	58.2
Suspended Solids	mg/l	2	1.5	4
T. Coli.	#/100ml	2	12	62
F. Coli.	#/100ml	2	2	2

THREE LAKES STUDY

Station: 26 Shadow Mountain/Granby Pump Canal

Date	Yr/Mo/Day	74/09/12	74/09/13	74/09/16
Time	Mtly.	0850	1030	1135
Temp.	Cent.	9.0	7.0	7.5
Flow	m^3/s	-	-	-
pH	SU	6.6	6.9	6.9
Conductivity	μmhos	72	64	66
DO	mg/l	7.2	5.3	5.3
BOD_5	mg/l	1.4	1.0	1.0
TKN	mg/l	0.23	0.30	0.21
NO_2+NO_3-N	mg/l	0.035	0.089	0.096
NH_3-N	mg/l	0.020	0.030	0.028
Total-P	mg/l	0.014	0.013	0.019
Ortho-P	mg/l	0.004	0.005	0.006
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	1.8	2.1	1.9
Alkalinity	mg/l	50.0	47.8	50.0
Suspended Solids	mg/l	4	4	3
T. Coli.	#/100ml	3	2	1
F. Coli.	#/100ml	1	<1	<1

Flow from Lake Granby to Shadow Mt. Lake

THREE LAKES STUDY

Station: 30 Recreation Area STP Evaporation Pond

Date	Yr/Mo/Day	74/09/12	74/09/13	74/09/16
Time	Mtly.	0930	1115	1245
Temp.	Cent.	7.0	13.0	15.0
Flow	m^3/s	*	*	*
pH	SU	7.8	9.6	8.7
Conductivity	μmhos	226	181	203
DO	mg/l	5.3	15.9	13.0
BOD_5	mg/l	48	12	22
TKN	mg/l	14.0	3.2	4.1
NO_2+NO_3-N	mg/l	0.191	0.006	0.005
NH_3-N	mg/l	1.00	0.038	0.065
Total-P	mg/l	1.96	0.940	1.10
Ortho-p	mg/l	0.500	0.688	0.76
Cl_2 Residual	mg/l	0.0	0.0	0.0
Turbidity	JTU	73.0	15.0	30
Alkalinity	mg/l	135	141	154
Suspended Solids	mg/l	456	96	90
T. Coli.	#/100ml	2800	800	25
F. Coli.	#/100ml	330	200	25

* No discharge

THREE LAKES STUDY

Station: 31 Colorado River at Shadow Mt. Lake

Date	Yr/Mo/Day	74/09/12	74/09/13	74/09/16
Time	Mtly.	0920	1130	1300
Temp.	Cent.	6.5	7.5	10.0
Flow	m^3/s	0.93	1.08	0.91
pH	SU	7.4	7.9	8.0
Conductivity	µmhos	90	85	85
DO	mg/l	9.3	9.1	8.7
BOD_5	mg/l	1.0	<1	1.0
TKN	mg/l	0.14	0.16	0.14
NO_2+NO_3-N	mg/l	0.003	0.003	0.003
NH_3-N	mg/l	0.019	0.028	0.026
Total-P	mg/l	0.018	0.014	0.015
Ortho-P	mg/l	0.005	0.008	0.005
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	2.0	2.6	2.5
Alkalinity	mg/l	60.0	62.0	71.0
Suspended Solids	mg/l	3	6	2
T. Coli.	#/100ml	43	19	7
F. Coli.	#/100ml	32	14	4

THREE LAKES STUDY

Station: 31-A Colorado River in Rocky Mountain National Park

Date	Yr/Mo/Day	74/09/12	74/09/13	74/09/16
Time	Mtly.	1145	1215	1400
Temp.	Cent.	5.5	8.0	8.0
Flow	m^3/s	-	-	0.59
pH	SU	7.5	6.9	5.4
Conductivity	µmhos	90	75	82
DO	mg/l	8.6	8.8	8.7
BOD_5	mg/l	<1	1.4	<1
TKN	mg/l	0.25	0.16	0.08
NO_2+NO_3-N	mg/l	0.004	0.003	0.003
NH_3-N	mg/l	0.020	0.032	0.027
Total-P	mg/l	0.015	0.011	0.016
Ortho-P	mg/l	0.005	0.004	0.003
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	2.6	2.6	3.2
Alkalinity	mg/l	58.0	54.0	64.0
Suspended Solids	mg/l	3	3	3
T. Coli.	#/100ml	43	27	6
F. Coli.	#/100ml	34	15	5

THREE LAKES STUDY

Station: 43 Grand Lake STP Effluent

Date	Yr/Mo/Day	74/09/12	74/09/13	74/09/16
Time	Mtly.	1000	1145	1315
Temp.	Cent.	12.0	11.0	10.0
Flow	m^3/s	-	-	0.02
pH	SU	6.5	6.8	6.7
Conductivity	μmhos	170	170	130
DO	mg/l	5.1	4.2	6.7
BOD_5	mg/l	15	17	12
TKN	mg/l	7.2	7.2	6.6
NO_2+NO_3-N	mg/l	0.087	0.075	0.073
NH_3-N	mg/l	4.48	4.17	3.52
Total-P	mg/l	2.28	1.74	1.36
Ortho-P	mg/l	1.28	1.11	0.760
Cl_2 Residual	mg/l	-	0.0	<1.0
Turbidity	JTU	20.1	7.1	9.5
Alkalinity	mg/l	85.0	100.0	66.0
Suspended Solids	mg/l	41	34	14
T. Coli.	#/100ml	110	810,000	130
F. Coli.	#/100ml	20	620,000	30

THREE LAKES STUDY

Station: 44 Little Columbine Creek near Grand Lake

Date	Yr/Mo/Day	74/09/12	74/09/13	74/09/16
Time	Mtly.	1010	1155	1320
Temp.	Cent.	8.0	9.0	10.0
Flow	m^3/s	*	*	*
pH	SU	7.0	7.5	7.4
Conductivity	μmhos	102	88	93
DO	mg/l	6.3	8.5	8.3
BOD_5	mg/l	1.5	1.2	<1
TKN	mg/l	0.26	0.37	0.23
NO_2+NO_3-N	mg/l	0.006	0.004	0.004
NH_3-N	mg/l	0.022	0.031	0.029
Total-P	mg/l	0.040	0.031	0.580
Ortho-P	mg/l	0.019	0.016	0.016
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	4.0	3.3	3.4
Alkalinity	mg/l	79.0	81.0	79.0
Suspended Solids	mg/l	7	9	6
T. Coli.	#/100ml	180	46	40
F. Coli.	#/100ml	140	44	30

* Flow appeared to be uniform throughout the study period, but was actually measured only on 9/18/74. The measured flow was 0.08 m^3/s.

THREE LAKES STUDY

Station: 52 Grand Lake North Inlet

Date	Yr/Mo/Day	74/09/17	74/09/18	74/09/19
Time	Mtly.	0940	0925	0915
Temp.	Cent.	5.0	6.0	5.5
Flow	m^3/s	-	0.37	-
pH	SU	6.8	7.0	7.3
Conductivity	µmhos	25	26	25
DO	mg/l	9.2	9.0	9.2
BOD_5	mg/l	<1	<1	<1
TKN	mg/l	0.09	0.16	0.22
NO_2+NO_3-N	mg/l	0.005	0.006	0.007
NH_3-N	mg/l	0.023	0.027	0.025
Total-P	mg/l	0.001	0.003	0.001
Ortho-P	mg/l	0.002	0.001	0.001
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	0.6	0.61	1.2
Alkalinity	mg/l	22.8	16.6	20.8
Suspended Solids	mg/l	<1	<1	1
T. Coli.	#/100ml	2	2	15
F. Coli.	#/100ml	1	2	7

THREE LAKES STUDY

Station: 57 Grand Lake East Inlet

Date	Yr/Mo/Day	74/09/17	74/09/18	74/09/19
Time	Mtly.	1110	1110	1030
Temp.	Cent.	6.5	7.0	6.0
Flow	m^3/s	-	0.29	-
pH	SU	6.5	6.6	7.3
Conductivity	µmhos	20	20	20
DO	mg/l	9.3	9.0	9.1
BOD_5	mg/l	<1	<1	<1
TKN	mg/l	0.12	0.12	0.20
NO_2+NO_3-N	mg/l	0.006	0.004	0.005
NH_3-N	mg/l	0.024	0.024	0.024
Total-P	mg/l	0.002	0.001	0.001
Ortho-P	mg/l	0.002	0.001	0.001
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	0.55	0.35	0.37
Alkalinity	mg/l	18.8	18.6	18.8
Suspended Solids	mg/l	1	1	1
T. Coli.	#/100ml	1	6	<1
F. Coli.	#/100ml	<1	5	<1

THREE LAKES STUDY

Station: 58 Colorado River Downstream Lake Granby

Date	Yr/Mo/Day	74/09/04	74/09/05	74/09/06
Time	Mtly.	1415	1235	1200
Temp.	Cent.	15.0	10.0	12.0
Flow*	m^3/s	0.24	0.24	0.24
pH	SU	7.7	7.1	6.6
Conductivity	μmhos	82	79	76
DO	mg/l	8.8	9.3	9.3
BOD_5	mg/l	<1	1.3	1.4
TKN	mg/l	0.40	0.28	0.34
NO_2+NO_3-N	mg/l	0.046	0.042	0.043
NH_3-N	mg/l	0.027	0.026	0.019
Total-P	mg/l	0.045	0.026	0.026
Ortho-P	mg/l	0.024	0.019	0.017
Cl_2 Residual	mg/l	-	-	-
Turbidity	JTU	2.5	1.5	1.7
Alkalinity	mg/l	67.0	58.0	56.0
Suspended Solids	mg/l	4	1.5	2
T. Coli.	#/100ml	22	2	8
F. Coli.	#/100ml	16	<1	3

* Flow values obtained from USGS.

THREE LAKES STUDY

Station: 2 Lake Granby - Arapaho Bay

Date	Yr/Mo/Day	74/09/04	74/09/05	74/09/06	74/09/04	74/09/05	74/09/06
Time	Mtly.	0835	0810	0825	0835	0810	0825
Depth		S	S	S	B	B	B
Temp.	Cent.	14.0	14.0	14.0	14.0	14.0	14.0
pH	SU	7.4	7.9	7.9	7.7	7.9	7.4
Conductivity	μmhos	55	56	55	54	55	53
DO	mg/l	7.4	7.5	7.3	7.1	7.6	7.3
TKN	mg/l	0.40	0.42	0.34	0.46	0.34	0.28
NO_2+NO_3-N	mg/l	0.001	0.001	0.002	<0.001	0.001	0.004
NH_3-N	mg/l	0.011	0.021	0.021	0.006	0.015	0.025
Total-P	mg/l	0.021	0.017	0.014	0.017	0.022	0.013
Ortho-P	mg/l	0.006	0.003	0.003	0.002	0.004	0.003
Alkalinity	mg/l	52.0	45.8	47.8	41.6	45.8	43.6
Turbidity	JTU	1.6	1.8	1.6	2.0	1.7	2.0
T. Coli.	#/100ml	<2	14	2	-	-	-
F. Coli.	#/100ml	<2	8	1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 4 Lake Granby - Transect at Twin Pines Point

Date	Yr/Mo/Day	74/09/04	74/09/05	74/09/06	74/09/04	74/09/05	74/09/06
Time	Mtly.	0905	0840	0840	0905	0840	0840
Depth		S	S	S	B	B	B
Temp.	Cent.	14.0	14.5	14.0	14.0	13.5	14.0
pH	SU	8.0	8.2	7.9	7.2	7.5	8.1
Conductivity	μmhos	55	58	58	56	58	59
DO	mg/l	7.8	7.6	7.7	7.5	6.4	7.8
TKN	mg/l	0.32	0.29	0.33	0.34	0.40	0.32
NO_2+NO_3-N	mg/l	<0.001	0.001	0.002	0.001	0.002	0.001
NH_3-N	mg/l	0.020	0.015	0.010	0.014	0.016	0.009
Total-P	mg/l	0.015	0.014	0.012	0.015	0.018	0.013
Ortho-P	mg/l	0.002	0.003	0.002	0.001	0.004	0.003
Alkalinity	mg/l	45.8	45.8	50.0	45.8	47.8	56.2
Turbidity	JTU	1.3	1.5	1.4	1.3	1.2	1.2
T. Coli.	#/100ml	<2	<1	<1	-	-	-
F. Coli.	#/100ml	<2	<1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 5 Lake Granby - Transect at Twin Pines Point

Date	Yr/Mo/Day	74/09/04	74/09/05	74/09/06	74/09/04	74/09/05	74/09/06	74/09/04	74/09/05	74/09/06
Time	Mtly.	0915	0850	0855	0915	0850	0855	0915	0850	0855
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	14.5	14.5	14.0	14.0	11.5	10.0	6.5	12.0	6.5
pH	SU	8.0	7.9	7.4	7.2	7.2	6.6	7.1	6.9	6.7
Conductivity	µmhos	55	58	58	55	55	59	59	54	63
DO	mg/l	7.7	7.7	7.9	7.5	4.9	4.7	4.8	4.8	4.9
TKN	mg/l	0.31	0.35	0.26	0.33	0.10	0.22	0.38	0.12	0.24
NO_2+NO_3-N	mg/l	0.001	0.001	0.002	0.001	0.020	0.044	0.099	0.093	0.095
NH_3-N	mg/l	0.019	0.022	0.008	0.029	0.015	0.016	0.019	0.018	0.019
Total-P	mg/l	0.013	0.014	0.015	0.016	0.013	0.013	0.042	0.019	0.021
Ortho-P	mg/l	<0.001	0.003	0.002	0.001	0.004	0.004	0.008	0.006	0.006
Alkalinity	mg/l	45.8	50.0	45.8	45.8	52.0	45.8	52.0	50.0	45.8
Turbidity	JTU	1.5	1.5	1.5	1.4	1.2	1.5	2.0	1.9	2.3
T. Coli.	#/100ml	2	2	<1	-	-	-	-	-	-
F. Coli.	#/100ml	2	<1	<1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 6 Lake Granby - Transect at Twin Pines Point

Date	Yr/Mo/Day	74/09/04	74/09/05	74/09/06	74/09/04	74/09/05	74/09/06
Time	Mtly.	0935	0900	0910	0935	0900	0910
Depth		S	S	S	B	B	B
Temp.	Cent.	14.5	14.5	14.0	15.0	13.5	14.0
pH	SU	8.0	7.9	7.7	7.9	7.4	7.9
Conductivity	µmhos	58	58	58	58	58	59
DO	mg/l	7.7	7.7	7.7	7.6	7.1	7.9
TKN	mg/l	0.36	0.13	0.25	0.37	0.26	0.28
NO_2+NO_3-N	mg/l	0.001	0.001	0.002	0.001	0.005	0.001
NH_3-N	mg/l	0.018	0.019	0.012	0.037	0.018	0.014
Total-P	mg/l	0.016	0.016	0.013	0.016	0.019	0.017
Ortho-P	mg/l	0.001	0.005	0.003	0.002	0.005	0.004
Alkalinity	mg/l	43.6	54.0	45.8	43.6	50.0	45.8
Turbidity	JTU	1.6	1.6	1.5	1.7	1.5	1.5
T. Coli.	#/100ml	<2	3	<1	-	-	-
F. Coli.	#/100ml	<2	<1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 7 Lake Granby - Transect at Rocky Point

Date	Yr/Mo/Day	74/09/04	74/09/05	74/09/06	74/09/04	74/09/05	74/09/06	74/09/04	74/09/05	74/09/06
Time	Mtly.	1005	0930	0935	1005	0930	0935	1005	0930	0935
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	15.0	14.5	14.5	11.5	13.0	11.0	10.0	8.5	7.5
pH	SU	7.7	7.9	7.9	7.4	7.7	7.1	7.3	7.4	7.0
Conductivity	µmhos	56	58	58	54	59	61	58	61	62
DO	mg/l	7.5	7.7	7.6	4.6	6.0	4.8	4.7	4.8	4.9
TKN	mg/l	0.28	0.26	0.22	0.31	0.20	0.24	0.54	0.30	0.26
NO_2+NO_3-N	mg/l	0.001	0.001	0.001	0.018	0.007	0.021	0.033	0.058	0.071
NH_3-N	mg/l	0.017	0.017	0.013	0.010	0.020	0.009	0.012	0.017	0.007
Total-P	mg/l	0.016	0.013	0.010	0.014	0.014	0.011	0.100	0.011	0.012
Ortho-P	mg/l	<0.001	0.004	0.003	0.001	0.004	0.003	0.007	0.004	0.004
Alkalinity	mg/l	45.8	60.4	45.8	45.8	47.8	47.8	50.0	54.0	47.8
Turbidity	JTU	1.4	1.4	1.2	0.84	1.3	1.2	13.0	0.9	1.1
T. Coli.	#/100ml	<2	<1	1	-	-	-	-	-	-
F. Coli.	#/100ml	<2	<1	<1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 8 Lake Granby - Transect at Rocky Point

Date	Yr/Mo/Day	74/09/04	74/09/05	74/09/06	74/09/04	74/09/05	74/09/06	74/09/04	74/09/05	74/09/06
Time	Mtly.	1020	0940	0945	1020	0940	0945	1020	0940	0945
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	15.0	14.0	14.0	13.0	11.5	11.0	12.0	7.0	7.0
pH	SU	7.4	7.9	7.4	7.0	7.4	6.9	7.4	7.4	6.8
Conductivity	µmhos	56	59	59	58	60	59	55	61	62
DO	mg/l	7.5	7.6	7.7	5.6	5.0	4.8	5.3	5.3	5.2
TKN	mg/l	0.33	0.20	0.24	0.28	0.20	0.33	0.24	0.14	0.29
NO_2+NO_3-N	mg/l	<0.001	0.002	0.002	0.005	0.016	0.024	0.112	0.106	0.096
NH_3-N	mg/l	0.013	0.012	0.010	0.012	0.014	0.016	0.015	0.013	0.010
Total-P	mg/l	0.010	0.013	0.010	0.015	0.014	0.008	0.022	0.013	0.007
Ortho-P	mg/l	<0.001	0.002	0.003	0.001	0.003	0.003	0.005	0.006	0.004
Alkalinity	mg/l	43.6	47.8	47.8	45.8	50.0	45.8	47.8	50.0	47.8
Turbidity	JTU	1.5	1.4	1.8	1.1	1.3	0.74	5.7	1.3	1.1
T. Coli.	#/100ml	<2	<2	<1	-	-	-	-	-	-
F. Coli.	#/100ml	<2	<1	<1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 9 Lake Granby - Transect at Rocky Point

Date	Yr/Mo/Day	74/09/04	74/09/05	74/09/06	74/09/04	74/09/05	74/09/06	74/09/04	74/09/05	74/09/06
Time	Mtly.	1035	0950	1000	1035	0950	1000	1035	0950	1000
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	14.5	14.0	14.5	13.0	12.0	11.0	6.5	6.5	6.0
pH	SU	7.4	7.9	7.6	7.2	7.4	6.9	7.1	7.1	6.7
Conductivity	µmhos	56	58	59	60	56	60	63	61	66
DO	mg/l	7.5	7.7	7.7	5.7	5.1	4.2	5.2	5.1	5.1
TKN	mg/l	0.42	0.20	0.24	0.30	0.19	0.22	0.30	0.10	0.19
NO_2+NO_3-N	mg/l	<0.001	0.001	0.002	0.014	0.019	0.020	0.118	0.107	0.111
NH_3-N	mg/l	0.023	0.013	0.012	0.011	0.016	0.012	0.011	0.020	0.015
Total-P	mg/l	0.011	0.011	0.009	0.013	0.011	0.005	0.013	0.014	0.013
Ortho-P	mg/l	<0.001	0.002	0.003	0.001	0.003	0.003	0.004	0.006	0.007
Alkalinity	mg/l	58.2	45.8	47.8	45.8	47.8	45.8	54.0	56.2	47.8
Turbidity	JTU	1.3	1.3	1.2	1.0	0.9	0.65	1.2	1.2	1.5
T. Coli.	#/100ml	<2	<1	<1	-	-	-	-	-	-
F. Coli.	#/100ml	<2	<1	<1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 10 **Lake Granby - Transect at Grand Bay**

Date	Yr/Mo/Day	74/09/04	74/09/05	74/09/06	74/09/04	74/09/05	74/09/06
Time	Mtly.	1055	1010	1025	1055	1010	1025
Depth		S	S	S	B	B	B
Temp.	Cent.	15.0	15.0	14.5	12.0	7.0	7.0
pH	SU	7.7	8.2	7.8	7.7	7.4	6.9
Conductivity	µmhos	56	59	60	60	66	63
DO	mg/l	7.8	8.1	7.7	6.4	3.7	4.0
TKN	mg/l	0.30	0.30	0.28	0.30	0.76	0.25
NO_2+NO_3-N	mg/l	<0.001	0.002	0.002	0.031	0.125	0.135
NH_3-N	mg/l	0.020	0.023	0.009	0.033	0.034	0.015
Total-P	mg/l	0.012	0.013	0.013	0.017	0.027	0.034
Ortho-P	mg/l	0.001	0.003	0.003	0.005	0.010	0.009
Alkalinity	mg/l	52.0	45.8	45.8	45.8	50.0	52.0
Turbidity	JTU	1.7	1.7	1.6	2.5	3.7	4.1
T. Coli.	#/100ml	<2	<1	<1	-	-	-
F. Coli.	#/100ml	<2	<1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 13 Lake Granby - Transect at Sunset Point

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11	74/09/09	74/09/10	74/09/11
Time	Mtly.	0950	0900	0845	0950	0900	0845
Depth		S	S	S	B	B	B
Temp.	Cent.	13.5	13.5	13.0	13.5	13.0	13.0
pH	SU	7.5	8.0	7.5	7.1	7.5	7.1
Conductivity	µmhos	60	58	62	59	60	61
DO	mg/l	7.6	7.4	7.4	7.2	7.3	7.5
TKN	mg/l	0.26	0.27	0.15	0.24	0.32	0.24
NO_2+NO_3-N	mg/l	0.001	0.002	0.002	0.001	0.002	0.002
NH_3-N	mg/l	0.017	0.016	0.017	0.018	0.016	0.017
Total-P	mg/l	0.012	0.018	0.009	0.029	0.020	0.010
Ortho-P	mg/l	0.001	0.002	0.001	0.002	0.003	0.001
Alkalinity	mg/l	43.6	47.8	47.8	45.8	50.0	45.8
Turbidity	mg/l	1.2	1.4	1.4	1.7	2.0	1.4
T. Coli.	#/100ml	1	<1	<1	-	-	-
F. Coli.	#/100ml	<1	<1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 14 Grand Lake - Transect at Sunset Point

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11	74/09/09	74/09/10	74/09/11	74/09/09	74/09/10	74/09/11
Time	Mtly.	1005	0910	0855	1005	0910	0855	1005	0915	0855
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	14.0	13.5	14.0	12.0	12.5	12.0	6.5	11.5	6.5
pH	SU	7.4	7.7	7.7	6.9	7.4	6.9	7.0	7.2	6.7
Conductivity	µmhos	60	60	59	61	60	61	63	55	63
DO	mg/l	7.6	7.7	7.6	5.8	6.4	5.9	5.2	5.1	4.8
TKN	mg/l	0.21	0.34	0.40	0.12	0.26	0.45	0.10	0.22	0.67
NO_2+NO_3-N	mg/l	0.001	0.002	0.001	0.012	0.006	0.009	0.112	0.115	0.106
NH_3-N	mg/l	0.013	0.015	0.017	0.018	0.016	0.018	0.014	0.015	0.022
Total-P	mg/l	0.012	0.014	0.009	0.015	0.019	0.009	0.013	0.012	0.013
Ortho-P	mg/l	0.001	0.002	0.001	0.005	0.004	0.001	0.005	0.005	0.005
Alkalinity	mg/l	45.8	47.8	45.8	47.8	47.8	45.8	47.8	47.8	45.8
Turbidity	JTU	1.3	1.4	1.3	1.5	1.2	1.1	1.2	1.4	1.8
T. Coli.	#/100ml	<1	<1	<1	-	-	-	-	-	-
F. Coli.	#/100ml	<1	<1	<1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 15 Lake Granby - Transect at Sunset Point

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11	74/09/09	74/09/10	74/09/11
Time	Mtly.	1015	0930	0930	1015	0930	0930
Depth		S	S	S	B	B	B
Temp.	Cent.	14.5	13.5	14.0	14.5	13.5	14.0
pH	SU	7.6	7.9	8.0	7.2	7.4	7.5
Conductivity	µmhos	60	61	60	58	60	60
DO	mg/l	7.7	7.8	7.7	7.8	7.8	7.8
TKN	mg/l	0.10	0.24	0.43	0.19	0.24	0.52
NO_2+NO_3-N	mg/l	0.002	0.004	0.003	0.002	0.002	0.002
NH_3-N	mg/l	0.018	0.016	0.016	0.020	0.016	0.020
Total-P	mg/l	0.011	0.013	0.008	0.026	0.022	0.014
Ortho-P	mg/l	0.001	0.002	<0.001	0.002	0.003	0.001
Alkalinity	mg/l	47.8	47.8	47.8	50.0	47.8	47.8
Turbidity	JTU	1.3	1.3	1.3	2.4	2.0	1.5
T. Coli.	#/100ml	<1	<1	<1	-	-	-
F. Coli.	#/100ml	<1	<1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 16 Lake Granby - Transect at Rainbow Bay

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11	74/09/09	74/09/10	74/09/11	74/09/09	74/09/10	74/09/11
Time	Mtly.	0935	0840	0830	0935	0840	0830	0935	0840	0830
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	13.0	13.0	13.0	13.0	13.5	13.0	7.5	8.0	7.0
pH	SU	7.6	7.8	7.7	7.1	7.4	7.4	6.9	7.2	7.1
Conductivity	μmhos	60	60	61	60	58	61	62	62	64
DO	mg/l	7.2	7.6	7.7	7.3	7.3	7.6	4.1	4.1	<4.1
TKN	mg/l	0.22	0.21	0.46	0.22	0.30	0.18	0.18	0.22	0.28
NO_2+NO_3-N	mg/l	0.002	0.003	0.002	0.002	0.003	0.002	0.100	0.098	0.095
NH_3-N	mg/l	0.015	0.013	0.020	0.021	0.014	0.018	0.026	0.016	0.021
Total-P	mg/l	0.016	0.008	0.010	0.013	0.013	0.010	0.023	0.018	0.027
Ortho-P	mg/l	0.001	0.003	<0.001	0.001	0.003	<0.001	0.006	0.007	0.006
Alkalinity	mg/l	47.8	47.8	47.8	45.8	52.0	45.8	47.8	47.8	47.8
Turbidity	JTU	2.0	1.4	1.6	1.5	1.4	1.3	3.9	3.0	3.6
T. Coli.	#/100ml	<1	<1	2	-	-	-	-	-	-
F. Coli.	#/100ml	<1	<1	<1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 17 Lake Granby - Transect at Kokanee Bay

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11
Time	Mtly.	0930	0830	0825
Depth		S	S	S
Temp.	Cent.	13.0	13.5	13.0
pH	SU	7.4	7.9	7.2
Conductivity	µmhos	60	60	61
DO	mg/l	7.4	7.8	7.7
TKN	mg/l	0.22	0.30	0.62
NO_2+NO_3-N	mg/l	0.003	0.004	0.002
NH_3-N	mg/l	0.028	0.016	0.019
Total-P	mg/l	0.013	0.018	0.013
Ortho-P	mg/l	0.001	0.003	<0.001
Alkalinity	mg/l	45.8	47.8	45.8
Turbidity	JTU	1.3	1.4	1.6
T. Coli.	#/100ml	5	1	<1
F. Coli.	#/100ml	<1	1	<1

S = Surface

Station: 18 Lake Granby - Between Kokanee and Fish Bays

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11	74/09/09	74/09/10	74/09/11
Time	Mtly.	0920	0825	0815	0920	0825	0815
Depth		S	S	S	B	B	B
Temp.	Cent.	13.5	13.5	13.0	13.0	13.0	13.0
pH	SU	7.5	8.0	7.9	7.4	7.8	7.8
Conductivity	µmhos	58	61	62	60	61	61
DO	mg/l	7.7	7.8	7.6	7.6	7.8	7.6
TKN	mg/l	0.14	0.27	0.38	0.08	0.30	0.24
NO_2+NO_3-N	mg/l	0.002	0.004	0.002	0.002	0.002	0.001
NH_3-N	mg/l	0.024	0.016	0.018	0.015	0.020	0.018
Total-P	mg/l	0.012	0.012	0.012	0.014	0.022	0.010
Ortho-P	mg/l	0.001	0.003	<0.001	0.001	0.002	0.001
Alkalinity	mg/l	47.8	47.8	45.8	47.8	47.8	47.8
Turbidity	JTU	1.6	1.6	1.7	1.5	1.6	1.6
T. Coli.	#/100ml	40	2	2	-	-	-
F. Coli.	#/100ml	35	2	2	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 19 Lake Granby - Transect Fish Bay to Rainbow Island

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11	74/09/09	74/09/10	74/09/11
Time	Mtly.	0910	0815	0805	0910	0815	0805
Depth		S	S	S	B	B	B
Temp.	Cent.	13.0	13.5	13.0	14.0	14.0	13.0
pH	SU	7.7	8.0	7.7	7.3	7.7	7.7
Conductivity	µmhos	56	61	63	56	60	61
DO	mg/1	7.6	7.8	7.6	7.6	7.9	7.5
TKN	mg/1	0.32	0.26	0.52	0.21	0.24	0.43
NO_2+NO_3-N	mg/1	0.002	0.003	0.002	0.002	0.002	0.002
NH_3-N	mg/1	0.021	0.021	0.22	0.020	0.016	0.017
Total-P	mg/1	0.014	0.012	0.012	0.014	0.015	0.014
Ortho-P	mg/1	0.001	0.002	0.001	0.002	0.002	0.001
Alkalinity	mg/1	47.8	47.8	47.8	47.8	47.8	45.8
Turbidity	JTU	1.5	1.8	1.8	1.4	2.0	2.3
T. Coli.	#/100ml	14	5	<1	-	-	-
F. Coli.	#/100ml	13	2	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 20 Lake Granby - Transect Fish Bay to Rainbow Island

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11	74/09/09	74/09/10	74/09/11
Time	Mtly.	1040	1020	0950	1040	1020	0950
Depth		S	S	S	B	B	B
Temp.	Cent.	15.0	15.0	15.0	14.0	15.0	14.0
pH	SU	7.4	7.8	7.5	7.1	7.5	7.1
Conductivity	µ mhos	58	59	61	61	59	60
DO	mg/l	7.8	7.9	7.6	7.3	7.3	7.2
TKN	mg/l	0.30	0.26	0.34	1.00	0.24	0.66
NO_2+NO_3-N	mg/l	0.003	0.003	0.003	0.004	0.003	0.003
NH_3-N	mg/l	0.023	0.019	0.018	0.033	0.019	0.018
Total-P	mg/l	0.014	0.011	0.010	0.154	0.015	0.015
Ortho-P	mg/l	0.002	0.001	0.001	0.010	0.002	0.004
Alkalinity	mg/l	47.8	64.4	47.8	47.8	47.8	47.8
Turbidity	JTU	1.8	1.6	1.6	4.2	1.5	1.4
T. Coli.	#/100ml	<1	<1	<1	-	-	-
F. Coli.	#/100ml	<1	<1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 21 Lake Granby - Transect Fish Bay to Rainbow Island

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11	74/09/09	74/09/10	74/09/11
Time	Mtly.	1030	1015	0940	1030	1015	0940
Depth		S	S	S	B	B	B
Temp.	Cent.	14.5	15.0	15.0	14.0	15.0	14.5
pH	SU	7.2	7.8	7.9	7.2	7.4	7.3
Conductivity	μ mhos	61	59	58	61	60	60
DO	mg/l	7.8	7.8	7.5	7.5	7.5	7.4
TKN	mg/l	0.21	0.30	0.28	0.32	0.46	0.52
NO_2+NO_3-N	mg/l	0.001	0.003	0.004	0.003	0.004	0.002
NH_3-N	mg/l	0.024	0.018	0.019	0.022	0.020	0.031
Total-P	mg/l	0.016	0.015	0.011	0.040	0.026	0.021
Ortho-P	mg/l	0.003	0.003	0.003	0.005	0.005	0.004
Alkalinity	mg/l	47.8	47.8	45.8	47.8	47.8	47.8
Turbidity	JTU	2.2	1.9	1.6	3.4	2.7	1.9
T. Coli.	#/100ml	<1	<1	<1	-	-	-
F. Coli.	#/100ml	<1	<1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 22 Lake Granby at Campground Launch Area

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11
Time	Mtly.	1105	1045	1020
Depth		S	S	S
Temp.	Cent.	15.0	15.5	15.5
pH	SU	7.6	7.8	7.9
Conductivity	µ mhos	60	59	58
DO	mg/l	7.6	7.8	7.6
TKN	mg/l	0.18	0.33	0.38
NO_2+NO_3-N	mg/l	0.002	0.003	0.002
NH_3-N	mg/l	0.025	0.018	0.021
Total-P	mg/l	0.010	0.014	0.012
Ortho-P	mg/l	0.002	0.003	0.003
Alkalinity	mg/l	47.8	50.0	47.8
Turbidity	JTU	2.6	1.8	1.7
T. Coli.	#/100ml	2	1	3
F. Coli.	#/100ml	2	1	1

S = Surface

THREE LAKES STUDY

Station: 23 Lake Granby at Cutthroat Trout Bay

Date	Yr/Mo/Day	74/09/09	74/09/10	74/09/11	74/09/09	74/09/10	74/09/11
Time	Mtly.	1050	1030	1005	1050	1030	1005
Depth		S	S	S	B	B	B
Temp.	Cent.	15.0	15.0	15.0	14.5	15.0	14.0
pH	SU	7.6	7.6	7.7	7.5	7.3	7.5
Conductivity	μ mhos	62	60	61	61	60	61
DO	mg/l	7.8	7.7	7.4	7.3	7.1	6.9
TKN	mg/l	0.22	0.32	0.26	0.32	0.30	0.21
NO_2+NO_3-N	mg/l	0.002	0.003	0.002	0.002	0.003	0.003
NH_3-N	mg/l	0.022	0.019	0.023	0.021	0.022	0.017
Total-P	mg/l	0.018	0.010	0.016	0.027	0.018	0.015
Ortho-P	mg/l	0.003	0.004	0.004	0.004	0.005	0.004
Alkalinity	mg/l	47.8	47.8	47.8	47.8	47.8	45.8
Turbidity	JTU	1.8	1.8	2.0	2.3	2.4	1.8
T. Coli.	#/100ml	4	22	13	-	-	-
F. Coli.	#/100ml	4	12	5	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 27 Shadow Mt. Lake - Transect at South End of Lake

Date	Yr/Mo/Day	74/09/12	74/09/13	74/09/16
Time	Mtly.	0825	0830	1000
Depth		S	S	S
Temp	Cent.	7.0	7.5	9.0
pH	SU	7.4	7.2	7.4
Conductivity	µmhos	63	63	62
DO	mg/l	7.2	7.0	7.9
TKN	mg/l	0.24	0.31	0.18
NO_2+NO_3-N	mg/l	0.031	0.023	0.007
NH_3-N	mg/l	0.021	0.029	0.024
Total-P	mg/l	0.016	0.014	0.015
Ortho-P	mg/l	0.004	0.004	<0.001
Alkalinity	mg/l	47.8	64.4	56.2
Turbidity	JTU	1.8	2.1	1.8
T. Coli.	#/100ml	3	15	2
F. Coli.	#/100ml	<1	<1	<1

S = Surface

THREE LAKES STUDY

Station: 28 Shadow Mt. Lake - Transect at South End of Lake

Date	Yr/Mo/Day	74/09/12	74/09/13	74/09/16	74/09/12	74/09/13	74/09/16
Time	Mtly.	0815	0820	0955	0815	0820	0955
Depth		S	S	S	B	B	B
Temp.	Cent.	7.0	6.5	8.0	7.0	7.0	8.0
pH	SU	7.5	7.1	7.1	7.3	7.2	7.3
Conductivity	µ mhos	64	64	63	64	63	62
DO	mg/l	6.8	6.7	6.4	6.7	6.2	6.3
TKN	mg/l	0.34	0.72	0.18	0.25	0.23	0.22
NO_2+NO_3-N	mg/l	0.046	0.049	0.028	0.045	0.053	0.053
NH_3-N	mg/l	0.022	0.053	0.026	0.020	0.025	0.027
Total-P	mg/l	0.015	0.073	0.016	0.014	0.013	0.019
Ortho-P	mg/l	0.003	0.048	<0.001	0.003	0.004	0.001
Alkalinity	mg/l	52.0	72.0	56.2	50.0	54.0	50.0
Turbidity	JTU	1.6	2.1	1.8	1.6	1.9	2.0
T. Coli.	#/100ml	6	2	2	-	-	-
F. Coli.	#/100ml	2	<2	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 29 Shadow Mt. Lake - Transect at South End of Lake

Date	Yr/Mo/Day	74/9/12	74/9/13	74/9/16
Time	Mtly.	0810	0815	0950
Depth		S	S	S
Temp.	Cent.	7.0	6.5	8.0
pH	SU	7.5	7.3	7.2
Conductivity	µ mhos	64	68	61
DO	mg/l	7.1	6.6	7.6
TKN	mg/l	0.26	0.30	0.17
NO_2+NO_3-N	mg/l	0.047	0.049	0.046
NH_3-N	mg/l	0.021	0.038	0.029
Total-P	mg/l	0.015	0.013	0.014
Ortho-P	mg/l	0.004	0.004	<0.001
Alkalinity	mg/l	50.0	50.0	54.0
Turbidity	JTU	1.6	2.1	1.9
T. Coli.	#/100ml	16	5	<1
F. Coli.	#/100ml	8	1	<1

S = Surface

THREE LAKES STUDY

Station: 32 Shadow Mt. Lake - Transect at North Side of Islands

Date	Yr/Mo/Day	74/9/12	74/9/13	74/9/16
Time	Mtly	0850	0855	1025
Depth		S	S	S
Temp	Cent	9.0	8.5	10.0
pH	SU	7.8	7.4	8.3
Conductivity	µ mhos	68	73	66
DO	mg/1	7.9	8.5	8.8
TKN	mg/1	0.26	0.18	0.22
NO_2+NO_3-N	mg/1	0.003	0.001	<0.001
NH_3-N	mg/1	0.018	0.031	0.027
Total-P	mg/1	0.018	0.014	0.026
Ortho-P	mg/1	0.004	0.003	<0.001
Cl_2-Residual	mg/1	-	-	-
Alkalinity	mg/1	54.0	66.6	64.4
Turbidity	JTU	2.5	2.2	2.0
T Coli	#/100ml	8	22	2
F Coli	#/100ml	<2	8	1

S = Surface

THREE LAKES STUDY

Station: 33 Shadow Mt. Lake - Transect at North Side of Islands

Date	Yr/Mo/Day	74/9/12	74/9/13	74/9/16	74/9/12	74/9/13	74/9/16
Time	Mtly	0840	0845	1015	0840	0845	1015
Depth		S	S	S	B	B	B
Temp	Cent	9.0	9.0	10.0	9.0	9.0	9.5
pH	SU	7.7	7.0	7.1	7.7	7.2	7.1
Conductivity	μ mhos	66	64	63	66	64	66
DO	mg/l	7.8	7.9	8.2	7.5	7.8	8.1
TKN	mg/l	0.24	0.26	0.18	0.22	0.28	0.25
NO_2+NO_3-N	mg/l	0.008	0.001	<0.001	0.012	0.001	0.005
NH_3-N	mg/l	0.021	0.031	0.028	0.024	0.034	0.030
Total-P	mg/l	0.015	0.016	0.014	0.017	0.020	0.019
Ortho-P	mg/l	0.002	0.002	<0.001	0.003	0.003	0.002
Cl_2-Residual	mg/l	-	-	-	-	-	-
Alkalinity	mg/l	54.0	47.8	87.0	50.0	60.4	54.0
Turbidity	JTU	2.0	2.1	2.0	1.8	2.1	2.1
T Coli	#/100ml	<1	3	<2	-	-	-
F Coli	#/100ml	<1	<1	<2	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 34 Shadow Mt. Lake - Transect at North Side of Islands

Date	Yr/Mo/Day	74/9/12	74/9/13	74/9/16
Time	Mtly	0835	0840	1010
Depth		S	S	S
Temp	Cent	8.0	9.0	10.0
pH	SU	7.5	7.6	7.6
Conductivity	µ mhos	66	64	66
DO	mg/l	7.4	8.0	8.5
TKN	mg/l	0.20	0.32	0.28
NO_2+NO_3-N	mg/l	0.016	0.001	<0.001
NH_3-N	mg/l	0.020	0.030	0.028
Total-P	mg/l	0.015	0.018	0.017
Ortho-P	mg/l	0.003	0.003	0.001
Cl_2-Residual	mg/l	-	-	-
Alkalinity	mg/l	60.4	56.2	60.4
Turbidity	JTU	1.6	2.1	2.0
T Coli	#/100ml	1	8	<1
F Coli	#/100ml	<1	<1	<1

S = Surface

THREE LAKES STUDY

Station: 35 Shadow Mt. Lake - At Boat Docks West Side of Lake

Date	Yr/Mo/Day	74/9/12	74/9/13	74/9/16
Time	Mtly	0855	0900	1030
Depth		S	S	S
Temp	Cent	9.0	9.0	10.5
pH	SU	7.7	7.3	7.7
Conductivity	µ mhos	66	64	62
DO	mg/l	7.0	7.6	8.3
TKN	mg/l	0.26	0.22	0.20
NO_2+NO_3-N	mg/l	0.003	0.001	0.001
NH_3-N	mg/l	0.026	0.031	0.029
Total-P	mg/l	0.020	0.016	0.018
Ortho-P	mg/l	0.005	0.003	0.002
Cl_2-Residual	mg/l	-	-	-
Alkalinity	mg/l	50.0	52.0	52.0
Turbidity	JTU	2.8	2.3	2.3
T Coli	#/100ml	9	13	<1
F Coli	#/100ml	1	<1	<1

S = Surface

THREE LAKES STUDY

Station: 36 Shadow Mt. Lake - Transect at Center of Lake

Date	Yr/Mo/Day	74/9/12	74/9/13	74/9/16
Time	Mtly	0905	0910	1040
Depth		S	S	S
Temp	Cent	9.5	9.5	10.5
pH	SU	7.5	7.5	7.5
Conductivity	µ mhos	64	64	64
DO	mg/l	7.6	7.9	8.3
TKN	mg/l	0.25	0.28	0.24
NO_2+NO_3-N	mg/l	0.004	0.001	<0.001
NH_3-N	mg/l	0.019	0.033	0.023
Total-P	mg/l	0.017	0.013	0.017
Ortho-P	mg/l	0.002	0.002	0.001
Cl_2-Residual	mg/l	-	-	-
Alkalinity	mg/l	58.2	71.0	71.0
Turbidity	JTU	2.0	2.3	2.1
T Coli	#/100ml	4	8	<1
F Coli	#/100ml	<1	<2	<1

S = Surface

THREE LAKES STUDY

Station: 37 Shadow Mt. Lake - Transect at Center of Lake

Date	Yr/Mo/Day	74/9/12	74/9/13	74/9/16	74/9/12	74/9/13	74/9/16
Time	Mtly	0915	0915	1045	0915	0915	1045
Depth		S	S	S	B	B	B
Temp	Cent	9.5	9.0	10.0	9.5	9.5	9.5
pH	SU	7.1	7.4	7.3	7.3	7.3	7.0
Conductivity	µmhos	64	64	63	64	63	63
DO	mg/l	7.6	8.0	8.1	8.0	7.9	8.3
TKN	mg/l	0.24	0.27	0.24	0.24	0.30	0.29
NO_2+NO_3-N	mg/l	0.006	0.002	0.001	0.006	0.003	<0.001
NH_3-N	mg/l	0.023	0.029	0.027	0.022	0.028	0.027
Total-P	mg/l	0.017	0.013	0.021	0.017	0.014	0.006
Ortho-P	mg/l	0.002	0.001	0.001	0.001	0.002	0.001
Cl_2-Residual	mg/l	-	-	-	-	-	-
Alkalinity	mg/l	52.0	62.4	52.0	52.0	56.2	50.0
Turbidity	JTU	1.8	2.0	1.6	2.0	2.1	1.8
T Coli	#/100ml	2	<1	<1	-	-	-
F Coli	#100/ml	<1	<1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 38 Shadow Mt. Lake - Transect at Center of Lake

Date	Yr/Mo/Day	74/9/12	74/9/13	74/9/16
Time	Mtly	0920	0930	1050
Depth		S	S	S
Temp	Cent	9.0	9.0	10.0
pH	SU	7.6	7.3	7.8
Conductivity	μ mhos	64	64	64
DO	mg/l	8.0	7.8	8.3
TKN	mg/l	0.22	0.30	0.18
NO_2+NO_3-N	mg/l	0.002	0.004	<0.001
NH_3-N	mg/l	0.020	0.026	0.025
Total-P	mg/l	0.015	0.013	0.015
Ortho-P	mg/l	0.001	0.002	0.001
Cl_2-Residual	mg/l	-	-	-
Alkalinity	mg/l	52.0	67.0	52.0
Turbidity	JTU	1.8	1.9	1.8
T Coli	#/100ml	6	3	1
F Coli	#/100ml	<1	<1	<1

S = Surface

THREE LAKES STUDY

Station: 39 Shadow Mt. Lake - At Boat Docks West Side of Lake

Date	Yr/Mo/Day	74/9/12	74/9/13	74/9/16
Time	Mtly.	1005	0955	1110
Depth		S	S	S
Temp.	Cent.	10.0	10.0	10.5
pH	SU	7.4	7.7	7.7
Conductivity	µmhos	64	64	63
DO	mg/l	7.7	8.2	8.4
TKN	mg/l	0.21	0.22	0.24
NO_2+NO_3-N	mg/l	0.003	0.001	0.001
NH_3-N	mg/l	0.018	0.027	0.028
Total-P	mg/l	0.017	0.014	0.016
Ortho-P	mg/l	0.002	0.002	0.002
Alkalinity	mg/l	60.4	83.2	52.0
Turbidity	JTU	1.8	1.8	2.1
T. Coli.	#/100ml	<1	6	3
F. Coli.	#/100ml	<1	<1	<1

S = Surface

THREE LAKES STUDY

Station: 40 Shadow Mt. Lake - Transect at North End of Lake

Date	Yr/Mo/Day	74/9/12	74/9/13	74/9/16
Time	Mtly.	0955	0950	1105
Depth		S	S	S
Temp.	Cent.	10.5	10.0	10.0
pH	SU	7.7	7.7	7.2
Conductivity	µmhos	64	63	66
DO	mg/l	7.8	7.9	7.6
TKN	mg/l	0.25	0.32	0.35
NO_2+NO_3-N	mg/l	0.003	0.001	0.002
NH_3-N	mg/l	0.018	0.026	0.024
Total-P	mg/l	0.018	0.015	0.018
Ortho-P	mg/l	0.001	0.002	0.003
Alkalinity	mg/l	54.0	56.2	52.0
Turbidity	JTU	2.0	2.1	2.5
T. Coli.	#/100ml	6	13	19
F. Coli.	#/100ml	5	2	10

S = Surface

THREE LAKES STUDY

Station: 41 Shadow Mt. Lake - Transect at North End of Lake

Date	Yr/Mo/Day	74/9/12	74/9/13	74/9/16
Time	Mtly.	0950	0940	1100
Depth		S	S	S
Temp.	Cent.	10.0	10.0	10.0
pH	SU	7.6	8.0	7.6
Conductivity	µmhos	64	63	63
DO	mg/1	8.0	8.0	8.0
TKN	mg/1	0.22	0.28	0.35
NO_2+NO_3-N	mg/1	0.003	0.002	<0.001
NH_3-N	mg/1	0.018	0.028	0.028
Total-P	mg/1	0.016	0.014	0.016
Ortho-P	mg/1	0.001	0.001	0.002
Alkalinity	mg/1	47.8	74.8	50.0
Turbidity	JTU	1.6	2.1	1.8
T. Coli.	#/100ml	<1	7	3
F. Coli.	#/100ml	<1	1	1

S = Surface

THREE LAKES STUDY

Station: 42 Shadow Mt. Lake - Transect at North End of Lake

Date	Yr/Mo/Day	74/9/12	74/9/13	74/9/16
Time	Mtly.	0945	0935	1055
Depth		S	S	S
Temp.	Cent.	10.0	10.0	10.5
pH	SU	8.5	8.9	8.9
Conductivity	µmhos	66	64	63
DO	mg/l	8.0	9.1	8.3
TKN	mg/l	0.24	0.22	0.19
NO_2+NO_3-N	mg/l	0.003	0.001	0.001
NH_3-N	mg/l	0.018	0.027	0.023
Total-P	mg/l	0.017	0.016	0.017
Ortho-P	mg/l	0.001	0.001	0.002
Alkalinity	mg/l	50.0	54.0	62.4
Turbidity	JTU	1.7	1.6	1.5
T. Coli.	#/100ml	6	43	6
F. Coli.	#/100ml	<1	3	<1

S = Surface

THREE LAKES STUDY

Station: 45 Grand Lake at Outlet Between Lakes

Date	Yr/Mo/Day	74/09/17	74/09/18	74/09/19
Time	Mtly.	0905	0855	0845
Depth		S	S	S
Temp.	Cent.	8.5	9.0	9.0
pH	SU	7.7	7.5	7.6
Conductivity	μ mhos	66	67	67
DO	mg/1	8.0	8.0	8.1
TKN	mg/1	0.20	0.36	0.40
NO_2+NO_3-N	mg/1	<0.001	0.002	0.004
NH_3-N	mg/1	0.024	0.032	0.038
Total-P	mg/1	0.008	0.014	0.010
Ortho-P	mg/1	0.003	0.005	0.001
Alkalinity	mg/1	52.0	52.0	47.8
Turbidity	JTU	1.5	2.4	2.3
T. Coli.	#/100ml	17	15	1
F. Coli.	#/100ml	1	3	1

S = Surface

THREE LAKES STUDY

Station: 46 Grand Lake - Transect at West End of Lake

Date	Yr/Mo/Day	74/09/17	74/9/18	74/09/19	74/09/17	74/09/18	74/09/19
Time	Mtly.	0915	0900	0850	0915	0900	0850
Depth		S	S	S	B	B	B
Temp.	Cent.	10.0	10.0	10.5	9.5	10.0	10.0
pH	SU	7.8	7.7	7.7	7.8	7.3	7.6
Conductivity	µ mhos	59	60	49	59	60	59
DO	mg/l	8.2	8.1	8.1	8.1	8.1	8.0
TKN	mg/l	0.22	0.31	0.31	0.29	0.38	0.97
NO_2+NO_3-N	mg/l	<0.001	0.003	0.001	<0.001	0.002	0.001
NH_3-N	mg/l	0.025	0.027	0.029	0.026	0.016	0.035
Total-P	mg/l	0.009	0.008	0.005	0.012	0.012	0.061
Ortho-P	mg/l	0.002	0.003	0.001	0.003	0.003	0.006
Alkalinity	mg/l	43.6	57.8	43.6	43.6	47.8	43.6
Turbidity	JTU	1.5	1.4	1.6	1.7	1.7	3.1
T. Coli.	#/100ml	6	1	4	-	-	-
F. Coli.	#/100ml	2	<1	1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 47 Grand Lake - Transect at West End of Lake

Date	Yr/Mo/Day	74/09/17	74/09/18	74/09/19	74/09/17	74/09/18	74/09/19	74/09/17	74/09/18	74/09/19
Time	Mtly.	0920	0905	0855	0920			0920	0905	0855
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	10.0	10.0	10.5	6.0	NO SAMPLE	NO SAMPLE	5.5	7.5	6.0
pH	SU	7.6	7.4	7.9	6.8			6.9	6.9	7.2
Conductivity	µ mhos	54	58	56	33			34	32	36
DO	mg/l	7.9	8.3	8.3	7.1			7.1	6.7	7.2
TKN	mg/l	0.20	0.32	0.33	0.10			0.18	0.24	0.20
NO_2+NO_3-N	mg/l	<0.001	0.001	0.001	0.039			0.051	0.026	0.058
NH_3-N	mg/l	0.027	0.027	0.029	0.040			0.028	0.036	0.031
Total-P	mg/l	0.006	0.006	0.005	0.004			0.014	0.004	0.003
Ortho-P	mg/l	0.001	0.002	0.002	0.002			0.003	0.003	0.002
Alkalinity	mg/l	41.6	43.6	43.6	25.0			27.0	25.0	27.0
Turbidity	JTU	0.75	1.3	1.5	0.55			1.4	0.55	1.1
T. Coli.	#/100ml	3	1	2	-			-	-	-
F. Coli.	#/100ml	1	1	<1	-			-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 48 Grand Lake - Transect at West End of Lake

Date	Yr/Mo/Day	74/09/17	74/09/18	74/09/19	74/09/17	74/09/18	74/09/19
Time	Mtly.	0930	0910	0905	0930	0910	0905
Depth		S	S	S	B	B	B
Temp.	Cent.	10.0	10.0	10.5	10.0	10.0	10.5
pH	SU	7.4	7.3	7.4	7.1	7.3	7.5
Conductivity	µ mhos	56	50	56	56	53	56
DO	mg/l	7.8	8.0	8.2	8.0	7.5	8.2
TKN	mg/l	0.20	0.45	0.22	0.24	0.34	0.49
NO_2+NO_3-N	mg/l	0.001	0.001	0.001	0.001	0.002	0.005
NH_3-N	mg/l	0.027	0.033	0.027	0.025	0.030	0.032
Total-P	mg/l	0.004	0.008	0.003	0.010	0.011	0.019
Ortho-P	mg/l	0.001	0.003	0.001	0.003	0.002	0.002
Alkalinity	mg/l	45.8	43.6	43.6	43.6	21.6	41.6
Turbidity	JTU	0.8	1.4	1.2	1.4	0.85	2.2
T. Coli.	#/100ml	8	1	<1	-	-	-
F. Coli.	#/100ml	2	1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 49 Grand Lake - Transect at Center of Lake

Date	Yr/Mo/Day	74/09/17	74/09/18	74/09/19	74/09/17	74/09/18	74/09/19
Time	Mtly.	1015	1025	0945	1015	1025	0945
Depth		S	S	S	B	B	B
Temp.	Cent.	10.0	12.0	10.5	10.0	11.0	11.0
pH	SU	7.3	7.6	7.6	7.0	7.3	7.5
Conductivity	µmhos	59	56	59	59	56	60
DO	mg/l	8.1	8.2	8.2	7.9	7.6	8.3
TKN	mg/l	0.25	0.27	0.24	0.16	0.27	0.30
NO_2+NO_3-N	mg/l	<0.001	0.001	0.001	0.001	0.003	0.001
NH_3-N	mg/l	0.027	0.029	0.028	0.030	0.030	0.032
Total-P	mg/l	0.006	0.010	0.004	0.007	0.011	0.007
Ortho-P	mg/l	0.001	0.002	<0.001	0.003	0.003	0.001
Alkalinity	mg/l	43.6	45.8	43.6	41.6	43.6	45.8
Turbidity	JTU	1.4	1.4	1.6	1.5	1.5	1.3
T. Coli.	#/100ml	1	<1	<1	-	-	-
F. Coli.	#/100ml	1	<1	<1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 50 Grand Lake - Transect at Center of Lake

Date	Yr/Mo/Day	74/09/17	74/09/18	74/09/19	74/09/17	74/09/18	74/09/19	74/09/17	74/09/18	74/09/19
Time	Mtly.	1000	1010	0930	1000	1010	0930	1000	1010	0930
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	10.0	12.0	10.5	7.0	9.0	7.5	4.0	4.0	4.0
pH	SU	7.3	7.1	7.2	7.0	6.9	6.7	6.7	6.9	6.6
Conductivity	μ mhos	47	56	60	31	32	33	56	56	56
DO	mg/l	8.1	8.1	8.3	6.9	6.8	6.9	3.5	3.1	1.7
TKN	mg/l	0.23	0.34	0.30	0.10	0.20	0.23	0.11	0.26	0.25
NO_2+NO_3-N	mg/l	0.001	0.001	0.001	0.020	0.018	0.024	0.209	0.216	0.253
NH_3-N	mg/l	0.027	0.023	0.031	0.032	0.032	0.032	0.028	0.035	0.058
Total-P	mg/l	0.003	0.007	0.004	0.002	0.004	0.001	0.001	0.018	0.001
Ortho-P	mg/l	0.001	0.001	<0.001	0.002	0.002	<0.001	0.001	0.005	<0.001
Alkalinity	mg/l	43.6	43.6	43.6	25.0	20.8	22.8	41.6	41.6	41.6
Turbidity	JTU	1.2	0.9	1.4	0.6	0.5	0.53	0.75	3.5	2.5
T. Coli.	#/100ml	3	<1	1	-	-	-	-	-	-
F. Coli.	#/100ml	1	<1	1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 51 Grand Lake - Transect at Center of Lake

Date	Yr/Mo/Day	74/09/17	74/09/18	74/09/19	74/09/17	74/09/18	74/09/19
Time	Mtly.	0955	1005	0925	0955	1005	0925
Depth		S	S	S	B	B	B
Temp.	Cent.	10.0	12.0	10.5	7.0	7.5	6.0
pH	SU	7.2	7.8	7.7	6.8	7.0	7.1
Conductivity	μmhos	56	53	56	32	33	37
DO	mg/l	8.0	8.3	8.3	7.1	7.0	7.2
TKN	mg/l	0.14	0.22	0.26	0.20	0.24	0.22
NO_2+NO_3-N	mg/l	0.001	0.001	0.002	0.036	0.029	0.062
NH_3-N	mg/l	0.031	0.037	0.032	0.027	0.036	0.034
Total-P	mg/l	0.004	0.005	0.003	0.007	0.004	0.003
Ortho-P	mg/l	0.001	0.001	<0.001	0.002	0.002	0.001
Alkalinity	mg/l	41.6	43.6	45.8	25.0	25.0	27.0
Turbidity	JTU	1.2	1.2	1.3	0.85	1.0	1.0
T. Coli.	#/100ml	7	<1	<1	-	-	-
F. Coli.	#/100ml	5	<1	<1	-	-	-

S = Surface   M = Thermocline   B = Bottom

THREE LAKES STUDY

Station: 53 Grand Lake - Transect at East End of Lake

Date	Yr/Mo/Day	74/09/17	74/09/18	74/09/19	74/09/17	74/09/18	74/09/19	74/09/17	74/09/18	74/09/19
Time	Mtly.	1025	1030	0950	1025	1030	0950	1025	1030	0950
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	11.5	12.0	10.5	8.0	8.0	7.0	6.0	7.0	6.0
pH	SU	7.8	7.7	7.8	6.7	7.1	7.0	6.9	7.1	6.8
Conductivity	µmhos	56	56	45	32	32	34	34	36	36
DO	mg/1	8.1	8.4	8.2	6.5	7.1	6.8	7.2	7.3	7.3
TKN	mg/1	0.24	0.24	0.24	0.19	0.12	0.18	0.25	0.14	0.22
NO_2+NO_3-N	mg/1	0.001	0.001	0.002	0.014	0.031	0.031	0.053	0.061	0.057
NH_3-N	mg/1	0.028	0.029	0.033	0.026	0.033	0.034	0.031	0.029	0.035
Total-P	mg/1	0.006	-	0.004	0.002	0.003	0.001	0.028	0.005	0.002
Ortho-P	mg/1	0.003	0.002	<0.001	0.001	0.002	0.001	0.003	0.002	0.001
Alkalinity	mg/1	41.6	45.8	45.8	25.0	22.8	25.0	27.0	29.2	35.4
Turbidity	JTU	1.5	1.4	1.2	0.4	0.5	0.64	1.3	1.0	0.55
T. Coli.	#/100ml	6	<1	<1	-	-	-	-	-	-
F. Coli.	#/100ml	5	<1	<1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 54 Grand Lake - Transect at East End of Lake

Date	Yr/Mo/Day	74/09/17	74/09/18	74/09/19	74/09/17	74/09/18	74/09/19	74/09/17	74/09/18	74/09/19
Time	Mtly.	1035	1040	1000	1035	1040	1000	1035	1040	1000
Depth		S	S	S	M	M	M	B	B	B
Temp.	Cent.	11.0	12.5	11.0	8.0	8.0	7.5	4.5	4.5	4.0
pH	SU	7.3	7.8	7.9	6.9	7.1	6.9	6.8	7.0	6.9
Conductivity	µ mhos	56	56	56	32	32	32	52	54	49
DO	mg/l	8.0	8.1	8.5	6.9	7.1	7.0	6.0	6.1	6.2
TKN	mg/l	0.18	0.24	0.32	0.10	0.19	0.32	0.22	0.20	0.22
NO_2+NO_3-N	mg/l	0.001	0.001	0.002	0.023	0.032	0.025	0.114	0.116	0.122
NH_3-N	mg/l	0.028	0.032	0.031	0.035	0.038	0.033	0.031	0.036	0.032
Total-P	mg/l	0.004	0.006	0.004	0.002	0.003	0.001	0.006	0.002	0.001
Ortho-P	mg/l	0.001	0.002	0.001	0.002	0.001	0.001	0.003	0.002	0.001
Alkalinity	mg/l	47.8	45.8	43.6	27.0	25.0	27.0	39.6	41.6	39.6
Turbidity	JTU	0.9	1.3	1.4	0.4	0.5	0.50	1.1	0.85	0.6
T. Coli.	#/100ml	5	1	<1	-	-	-	-	-	-
F. Coli.	#/100ml	4	1	<1	-	-	-	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 55 Grand Lake - Transect at East End of Lake

Date	Yr/Mo/Day	74/09/17	74/09/18	74/09/19	74/09/17	74/09/18	74/09/19
Time	Mtly.	1045	1050	1015	1045	1050	1015
Depth		S	S	S	B	B	B
Temp.	Cent.	12.0	12.0	11.0	10.5	11.5	6.0
pH	SU	7.2	7.6	7.9	7.2	7.5	7.1
Conductivity	μ mhos	53	56	56	51	56	34
DO	mg/l	7.9	8.2	8.3	7.2	8.2	7.2
TKN	mg/l	0.16	0.29	0.27	0.10	0.28	0.16
NO_2+NO_3-N	mg/l	0.002	0.001	0.001	0.003	0.002	0.052
NH_3-N	mg/l	0.027	0.034	0.029	0.028	0.031	0.033
Total-P	mg/l	0.004	0.005	0.006	0.006	0.009	0.003
Ortho-P	mg/l	0.001	0.001	0.001	0.002	0.003	0.001
Alkalinity	mg/l	43.6	43.6	43.6	41.6	41.6	25.0
Turbidity	JTU	1.1	0.9	1.6	1.1	0.9	0.65
T. Coli.	#/100ml	2	2	2	-	-	-
F. Coli.	#/100ml	2	<1	1	-	-	-

S = Surface M = Thermocline B = Bottom

THREE LAKES STUDY

Station: 56 Grand Lake - Inlet to Adams Tunnel

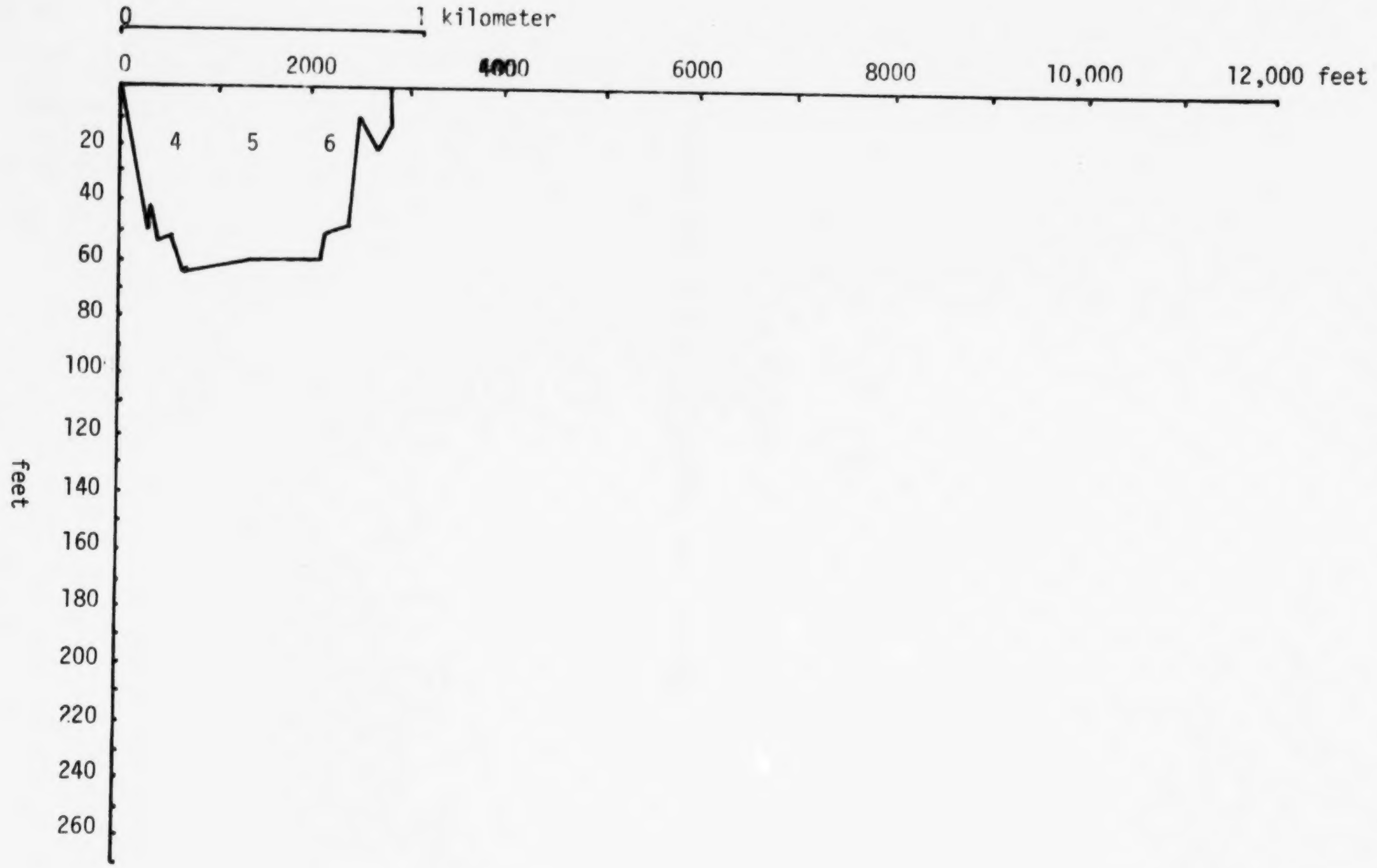
Date	Yr/Mo/Day	74/09/17	74/09/18	74/09/19	74/09/17	74/09/18	74/09/19
Time	Mtly.	1055	1100	1020	1055	1100	1020
Depth		S	S	S	B	B	B
Temp.	Cent.	12.0	12.0	12.0	10.5	11.5	11.0
pH	SU	7.3	7.3	7.7	7.4	7.3	7.6
Conductivity	μ mhos	52	56	54	56	56	56
DO	mg/1	8.0	8.2	8.3	8.0	8.2	8.1
TKN	mg/1	0.18	0.26	0.35	0.18	0.34	0.32
NO_2+NO_3-N	mg/1	0.003	0.001	0.002	0.002	0.001	0.002
NH_3-N	mg/1	0.028	0.030	0.030	0.031	0.031	0.031
Total-P	mg/1	0.004	0.002	0.006	0.006	0.006	0.010
Ortho-P	mg/1	0.002	0.001	0.001	0.003	0.002	0.001
Alkalinity	mg/1	43.6	41.6	43.6	47.8	43.6	43.6
Turbidity	JTU	0.9	1.1	1.7	1.2	1.4	1.6
T. Coli.	#/100ml	<1	2	1	-	-	-
F. Coli.	#/100ml	<1	2	1	-	-	-

S = Surface M = Thermocline B = Bottom

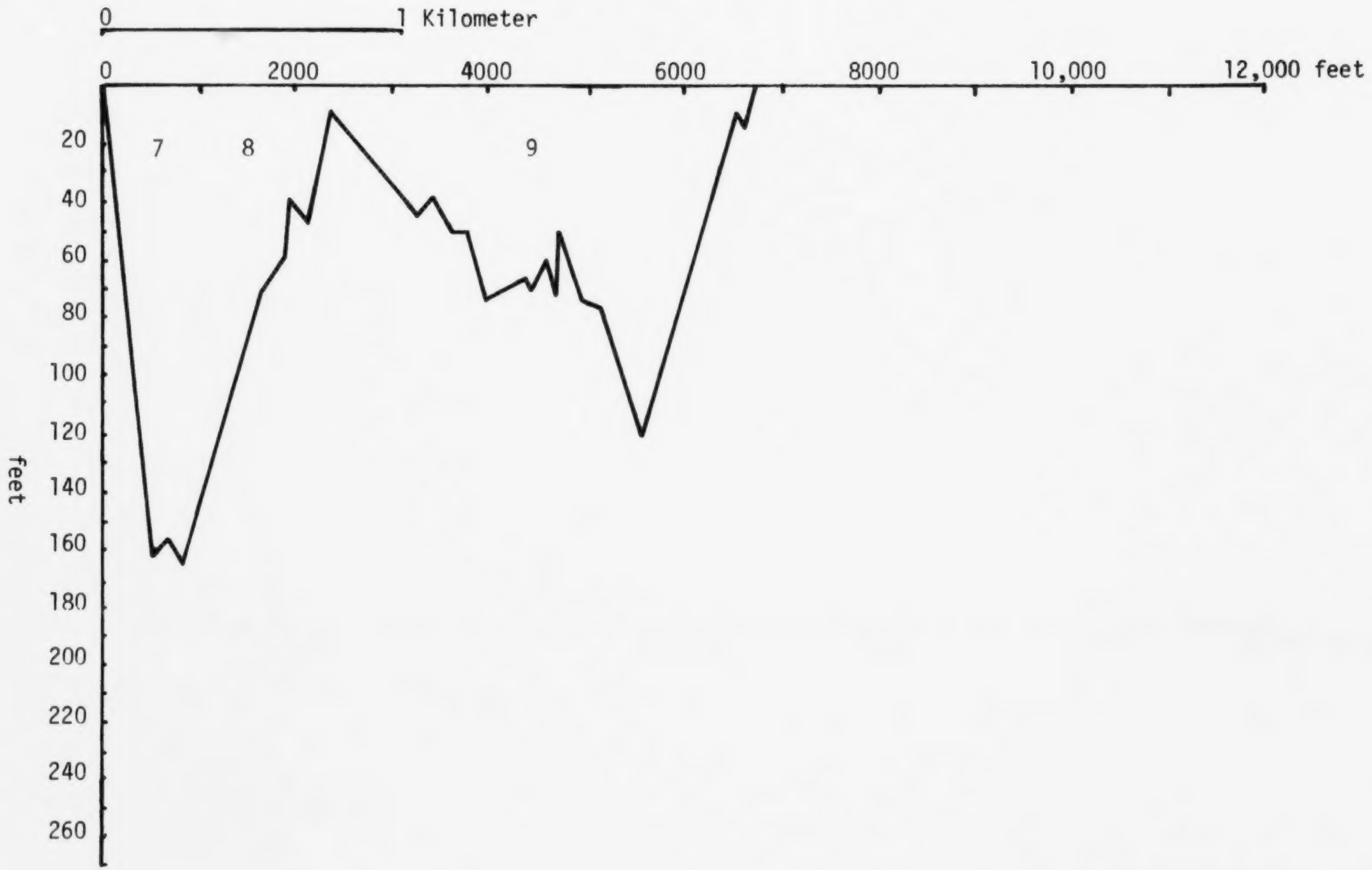
APPENDIX B

CROSS-SECTIONS, GRAND, SHADOW MOUNTAIN, GRANBY LAKES

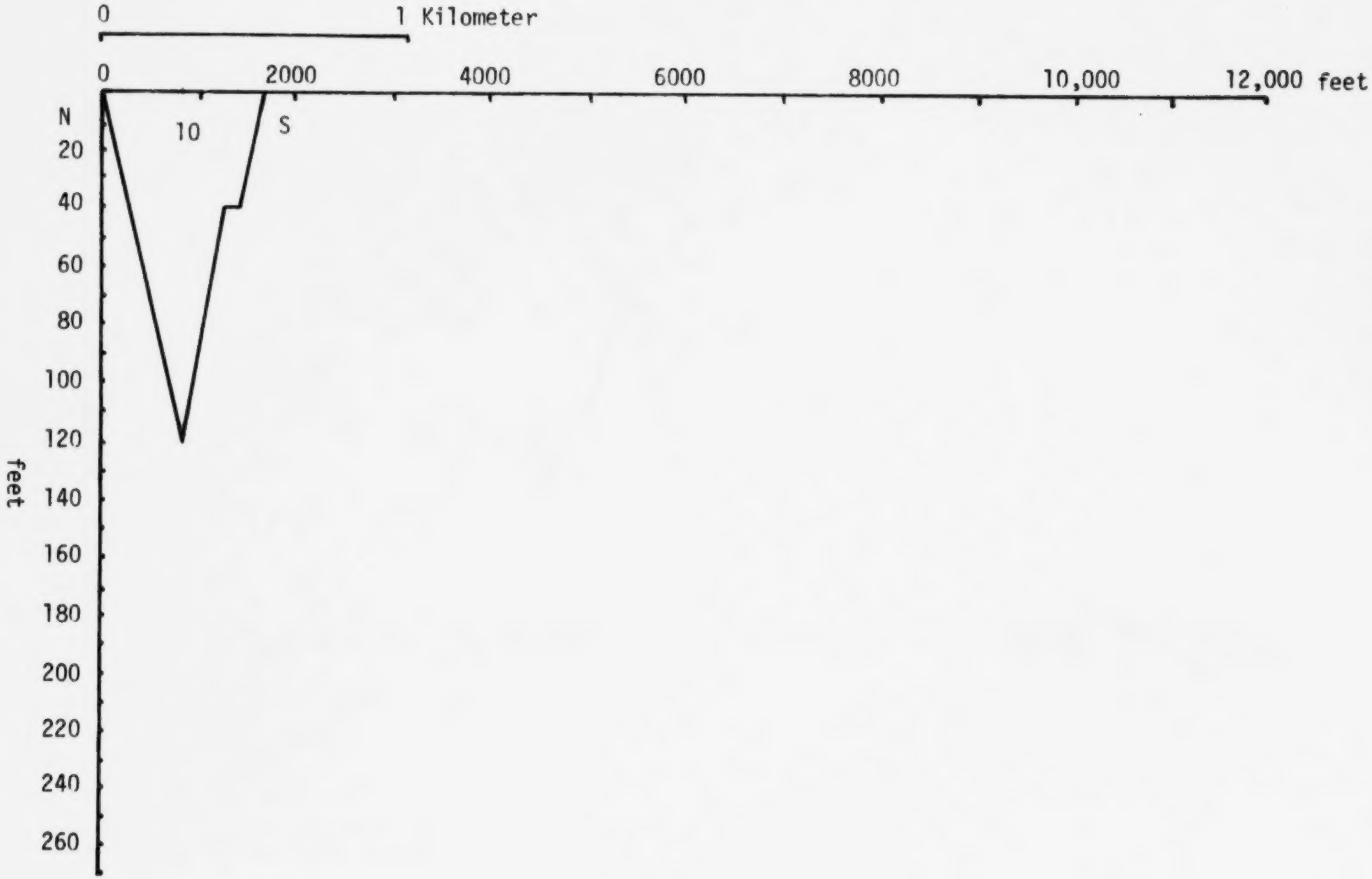
Lake Granby, Cross-Section at Twin Pines Point.



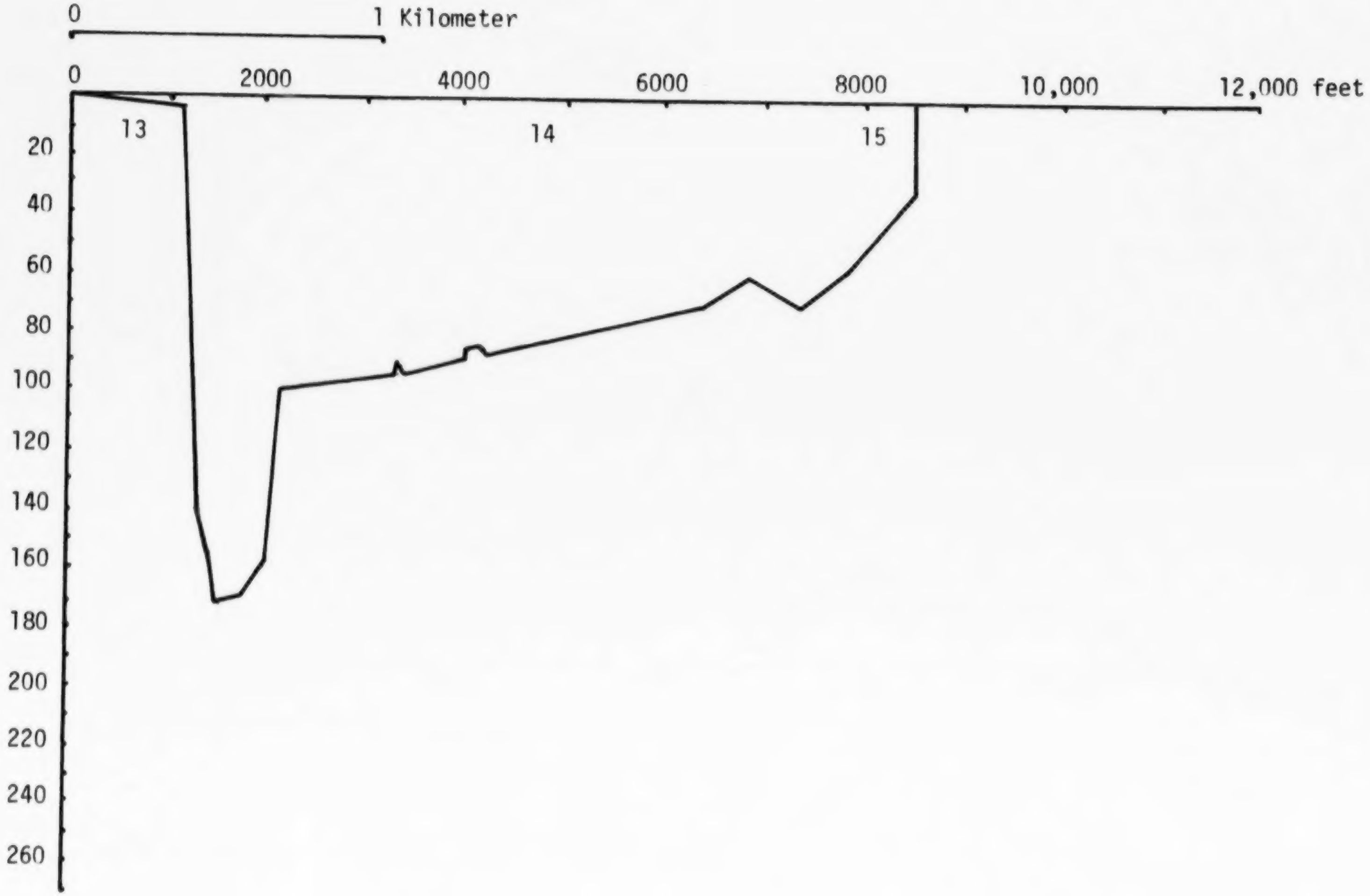
Lake Granby, Cross-Section at Rocky Point.



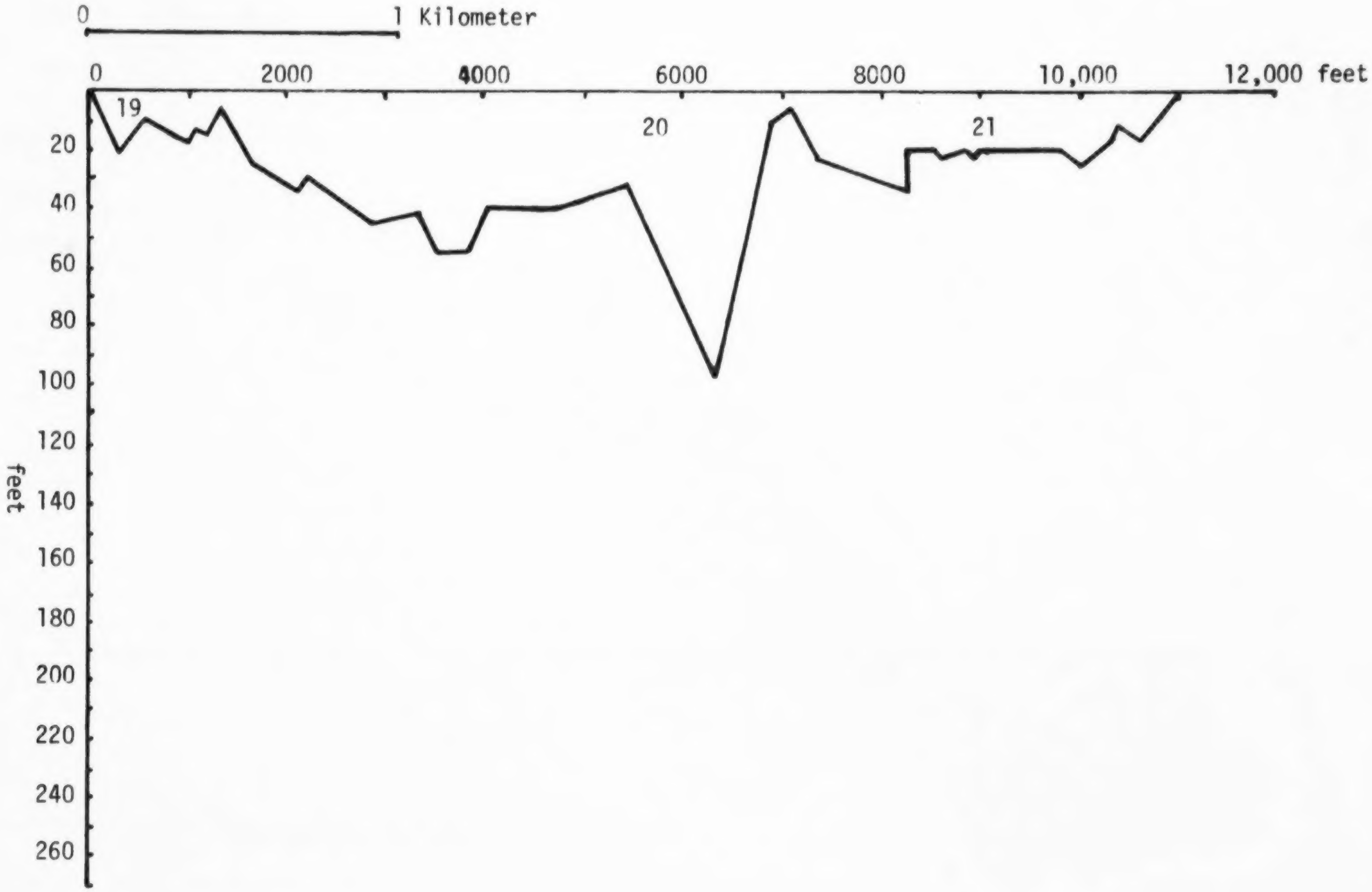
Lake Granby at Grand Bay.



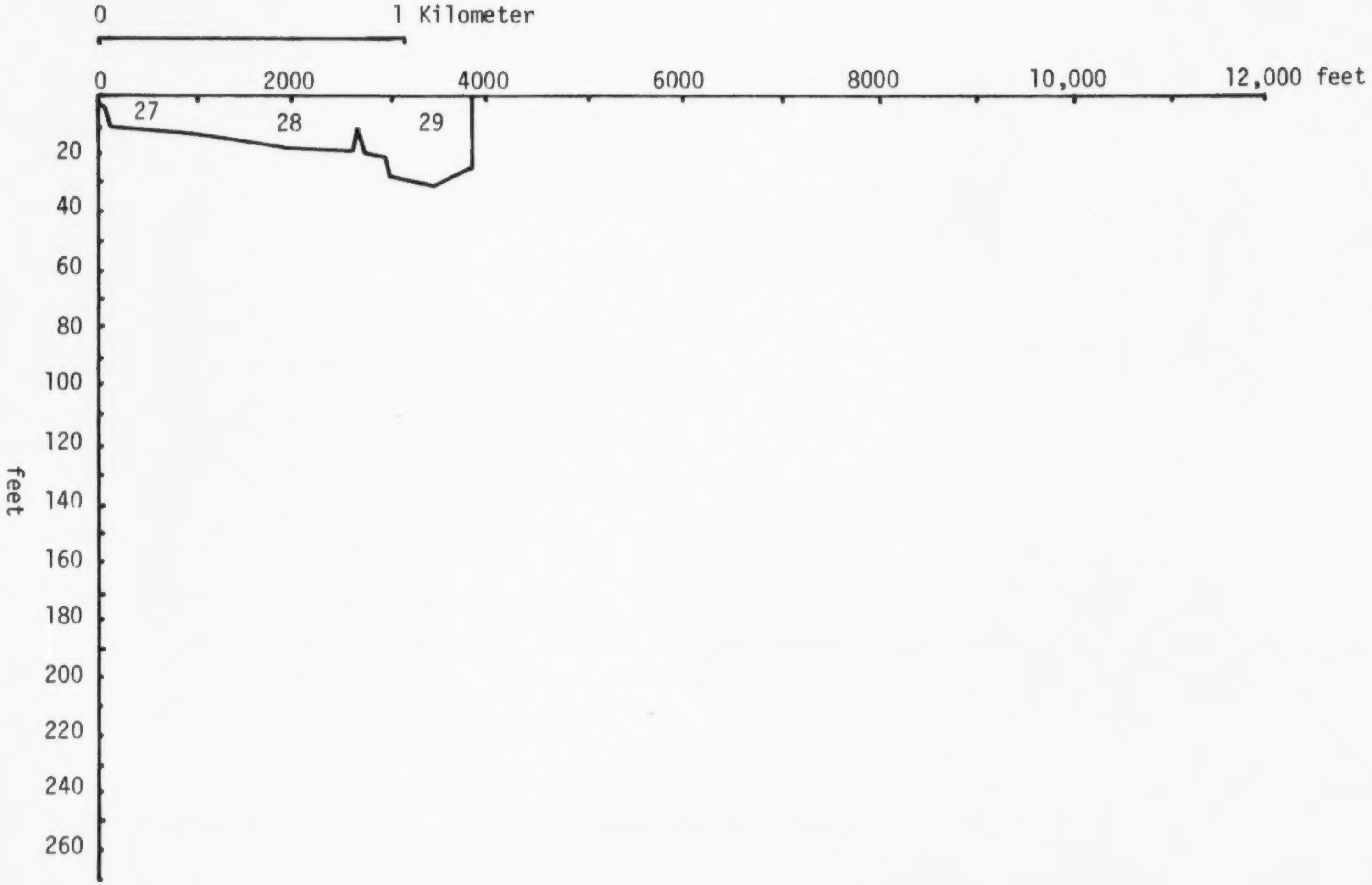
Lake Granby Cross-Section at Sunset Point.



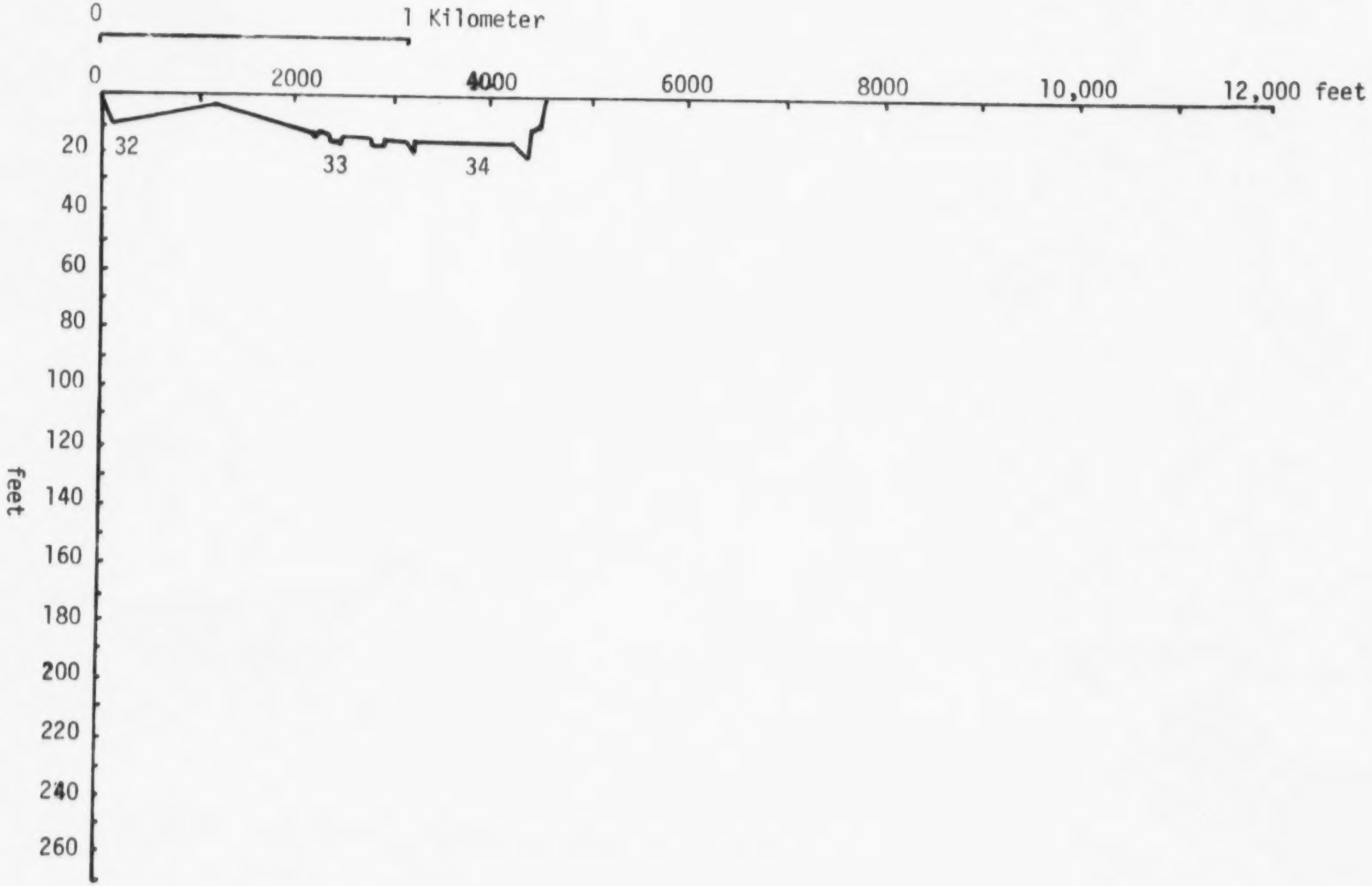
Lake Granby, Cross-Section Fish Bay to Rainbow Island.



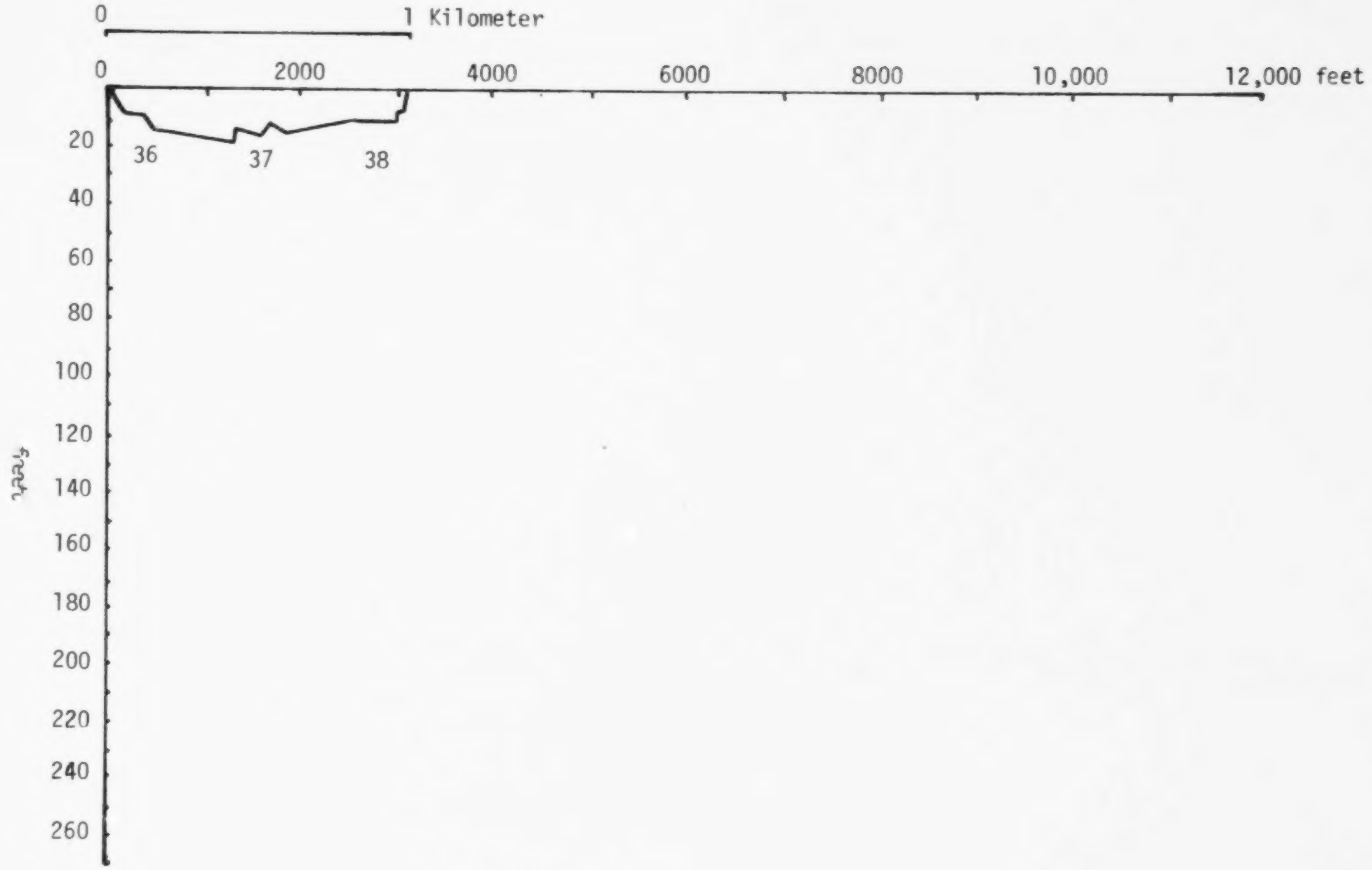
Shadow Mountain Lake, Cross-Section at South End of Lake.



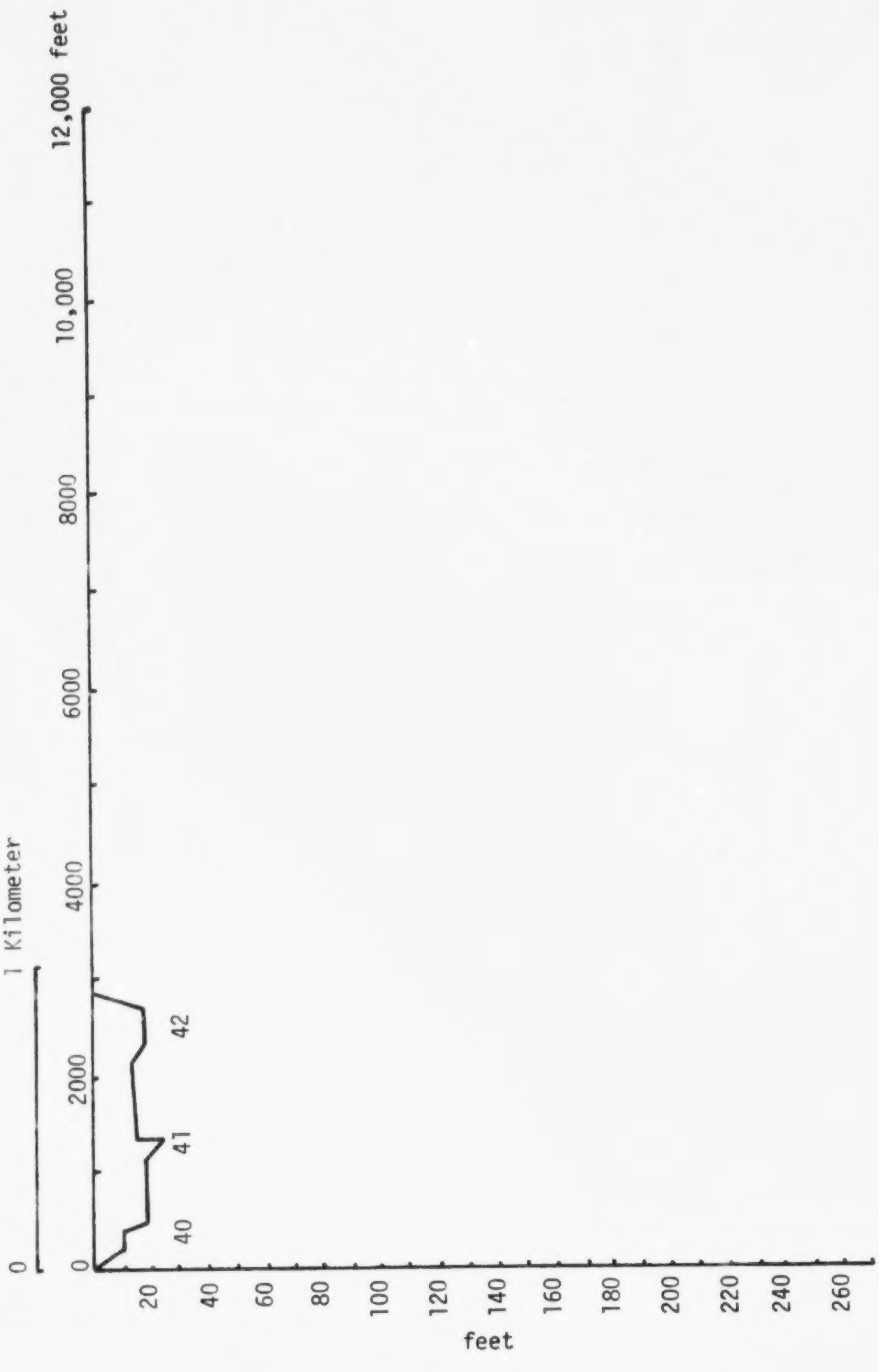
Shadow Mountain Lake, Cross-Section at North Side of Islands.



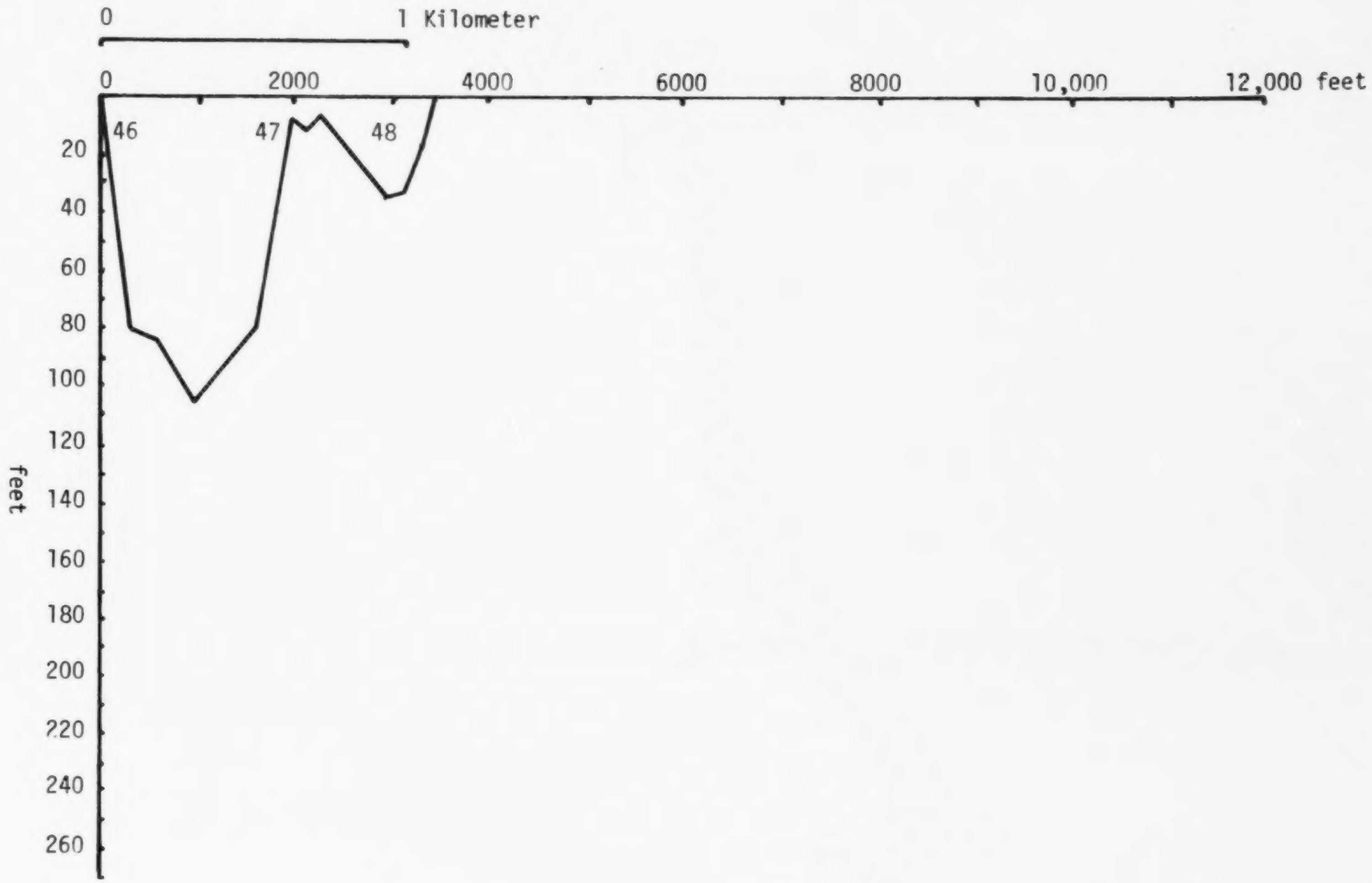
Shadow Mountain Lake, Cross-Section at Center of Lake.



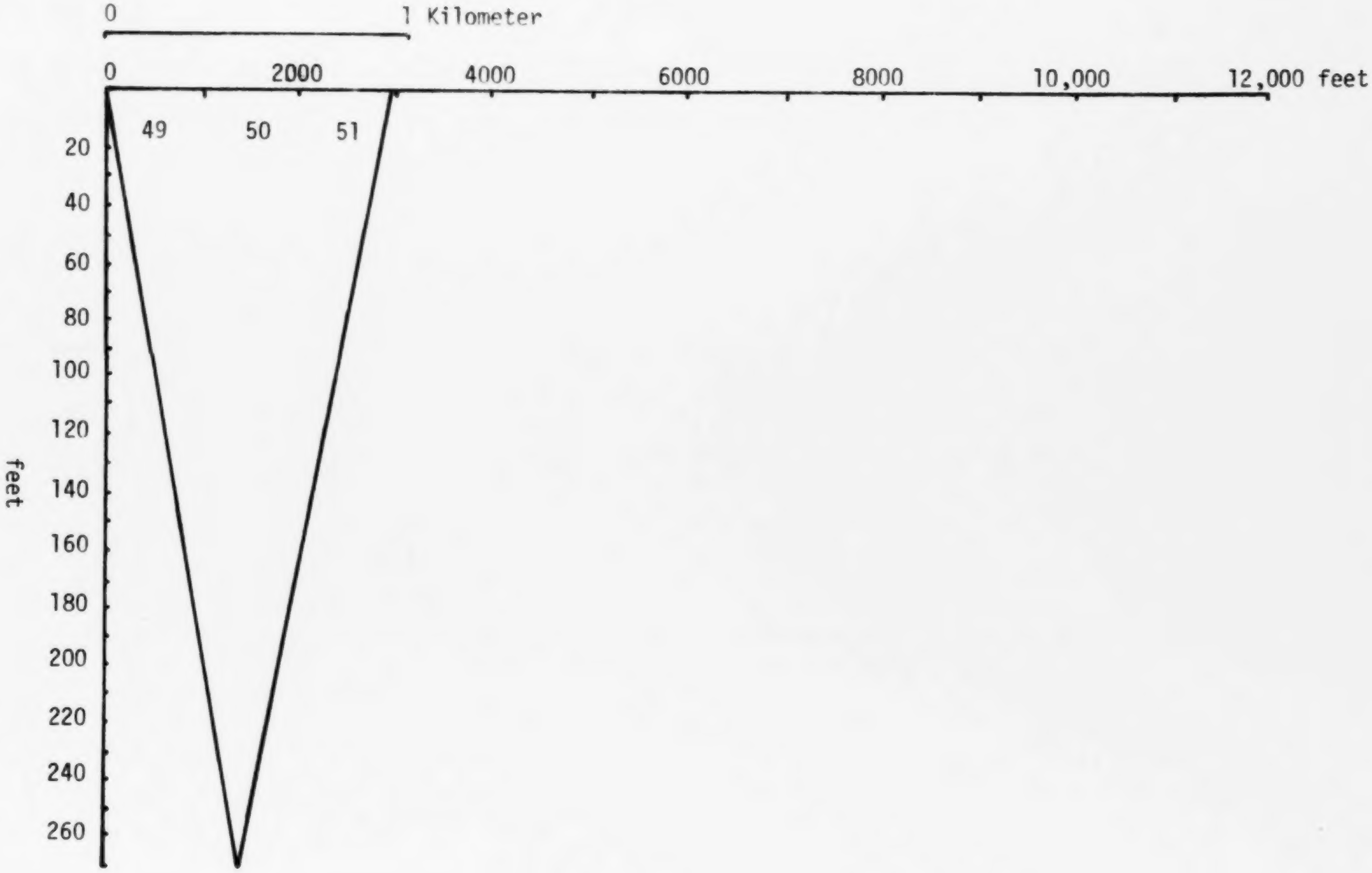
Shadow Mountain Lake, Cross-Section at North End of Lake.



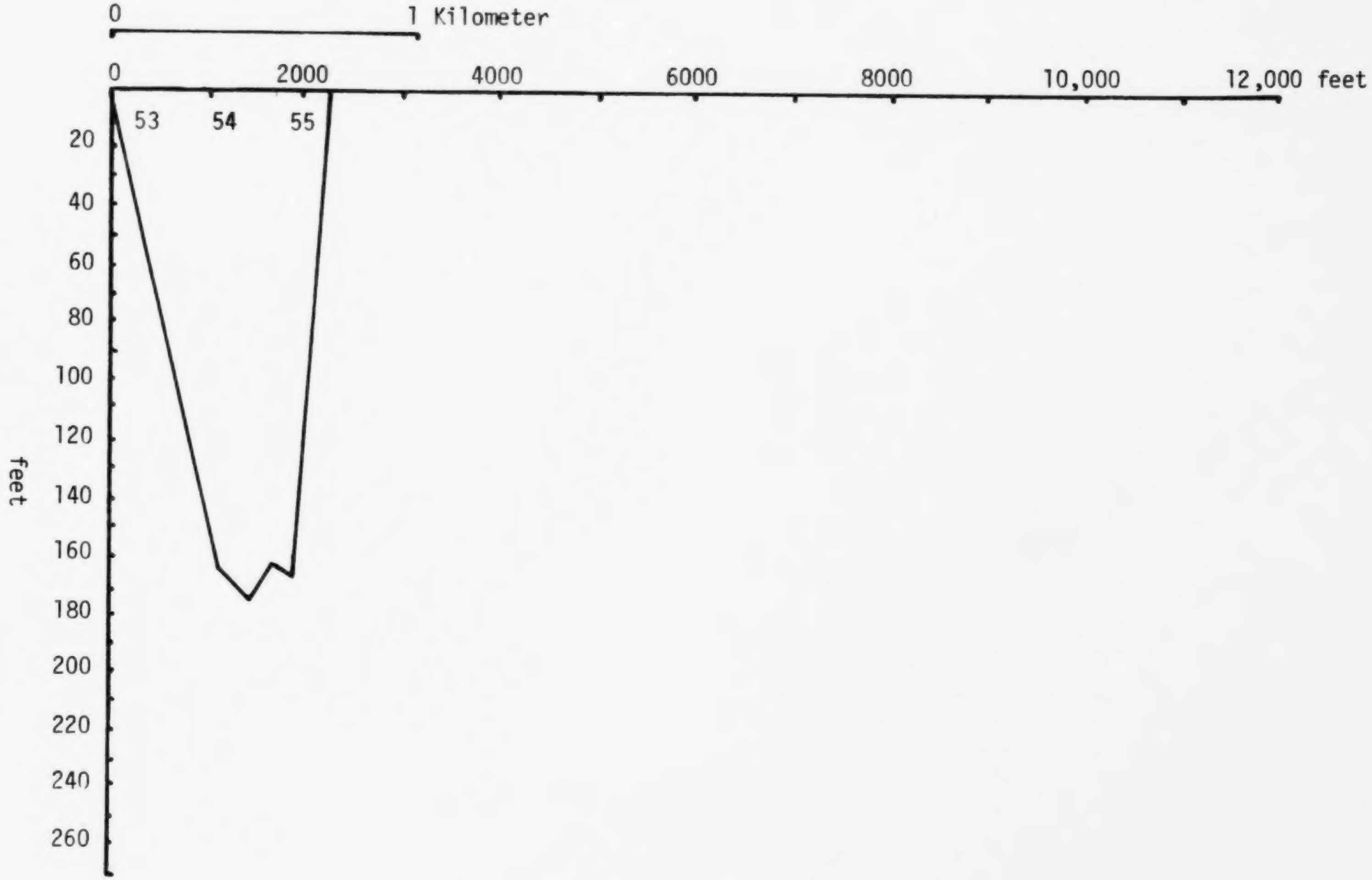
Grand Lake, Cross-Section at West End of Lake.



Grand Lake, Cross-Section at Center of Lake.



Grand Lake, Cross-Section at East End of Lake.



APPENDIX C

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